ENTOMOLOGY FOR MEDICAL OFFICERS

Διὸ δεῖ μὴ δυσχεραίνειν παιδικῶς τὴν περὶ τῶν ἀτιμοτέρων ζῴων ἐπίσκεψιν.

—ARISTOTLE, *De Partibus Animalium.*

"For that it is not meet childishly to crab the study of even the ignoble animals."

ENTOMOLOGY FOR MEDICAL OFFICERS

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TO

SIR PATRICK MANSON

K.C.M.G., F.R.S.

"*Grande decus columenque rerum.*"

"First he wroghte, and afterward he taughte;
But in his teching discreet and benigne."

PREFACE

THIS volume is printed in response to repeated requests from members of my classes at the London School of Tropical Medicine. Its aim is to provide, within convenient compass, a general account of those Arthropoda that, as a sequel to discoveries which have immortalised the names of Manson and Ross, every medical and sanitary officer who has to follow his vocation beyond the seas is now expected to look out for, to recognise, and to endeavour to control. It does not—or, at least, it is not intended to—trespass upon the domain of the physician, of the pathologist, of the sanitarian, or even of the protozoologist, but is chiefly concerned with that entomological territory where these empires meet.

The literature of Medical Entomology—using the term entomology in the old inclusive Latreillian sense—is now so enormous that I neither could nor would compile a bibliography of the subject; but the medical officer who is inclined for this kind of entomological research will find in the list of memoirs on pages 325-331—many of which are richly furnished with bibliographical appendices—something to set him on his way. To these memoirs I gladly acknowledge my own indebtedness, and I must also express my very great obligations to Mr E. E. Austen, of the British Museum, for the kind and generous aid that he has given me, during several years, in acquiring some practical experience of the species of *Diptera*.

The majority of the figures which—however inartistically—illustrate the text have been drawn from cleared specimens mounted in Canada balsam, such as students to whom entomology is a means rather than an end commonly make for themselves.

A. ALCOCK.

HEATHLANDS, BELVEDERE, KENT.

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ENTOMOLOGY FOR MEDICAL OFFICERS

CHAPTER I

Introduction

ALTHOUGH this book does not purport going much beyond the Arthropoda with which the medical officer is concerned, yet there are certain broad facts regarding the classification and geographical distribution of animals, the characters and relations of the Arthropod Phylum, and the general bearing of Arthropoda on human pathology, that have to be considered very briefly by way of introduction.

I.—CLASSIFICATION OF ANIMALS.

Animals are arranged in two primary series. The one series—PROTOZOA—includes animals that consist either of a single cell or of a small aggregate of cells that show little or no diversity; the other series—METAZOA—includes animals that begin life as a single cell, which gradually develops into an organised community of diversified cells.

The *Metazoa* again are arranged in two series. The one series consists of animals like the Sponges (PORIFERA), which are composed of groups of cells scattered without any definite bond of union in an overwhelming mass of inapt intercellular substance; the other series—ENTEROZOA—consists of animals that have a body-wall composed of definite and adjusted elements, and—certain degraded parasites being left out of account—a mouth and a well-defined digestive-cavity.

The *Enterozoa* again are arranged in two series. The one series includes animals like the polyps, sea-anemones, and jelly-fishes (CŒLENTERATA) in which the cavity enclosed by the body-wall is the digestive-cavity; the other series—CŒLOMATA—includes animals whose body-wall encloses a body-cavity, or *Cœlom*, which has definite functions, and is quite distinct from the digestive-cavity that passes through it or is suspended in it.

Of the animals usually reckoned among the *Cœlomata*, however, there are some, such as the flat-worms, in which the body "cavity" is parenchymatous. In some of the parasitic flat-worms, too, as also in some of the parasitic round-worms, mouth and digestive-cavity do not exist.

Protozoa, Porifera, and Cœlenterata constitute three several *phyla* of the animal kingdom. The Cœlomata are also split up into numerous phyla (φῦλον = a clan, or stock). Of the Cœlomata phyla some are vigorous and prolific stocks, while others are of the nature of stunted shoots or insignificant relics. Of the great phyla the principal are: (1) the VERTEBRATA which possess at least the prospective elements of a backbone and skull; (2) the MOLLUSCA, or soft-bodied unsegmented animals like the snail and oyster, which are enveloped in a mantle and shell; (3) the ECHINODERMATA, or radially-symmetrical Cœlomates, like the star-fishes and sea-urchins; (4) the ARTHROPODA, or segmented animals with firm exoskeleton and segmented appendages; (5) the ANNELIDA, or segmented worms; (6) the NEMATHELMINTHES, or parasitic round-worms; and (7) the PLATYHELMINTHES, or parasitic flat-worms. The minor phyla include a number of small, chiefly marine groups, such as the *Sipunculoidea*, *Chætognatha*, *Polyzoa*, and *Brachiopoda;* also the *Rotifera*, all of which are cousin with the Annelid stock; and the *Enteropneusta*, *Tunicata* (or Ascidians), and *Cephalochorda* (Lancelet), which are satellites of the Vertebrate system.

On the theory of Evolution the members of all the phyla, from the simplest Protozoon to the most specialised vertebrate, are regarded as descendants of a far-remote ancestor, so that the whole world is kin; and the existing phyla are supposed to represent the unperished limbs of a great genealogical

tree, whose trunk is buried in the past, and many of whose twigs and branches have decayed.

Every large phylum, again, can be resolved into a number of smaller groups all of which differ from one another, though they agree in fundamental points of structure. Such large groups within the phylum are known as *Classes*.

Every large Class, again, is composed of a number of smaller groups, or *Orders*, all of which, beyond their common class-features, have their own distinctive peculiarities.

Every large Order, again, can be split into smaller groups, or *Families*, and every large Family into *Genera*, and every large Genus into *Species*, which are the ultimate units of ordinary classification.

As with the phylum, so with its subdivisions; on the theory of Evolution the successive subdivisions are supposed to represent minor branches and shoots of the great genealogical tree, and the constituent members of each subdivision are regarded as the descendants of a common ancestor in their own degree, the final series, or *species*, being the collateral descendants of the supposed grand-ancestor of the phylum.

The successive subdivisions of the animal kingdom are not to be taken as concrete objects, but as abstractions representing a narrowing series of *general concepts*. What the zoologist deals with are individual animals, and these after due examination he labels as species, and pigeon-holes in genus, family, order, and so on; and since every man's concepts are his own, it is inevitable that there must be considerable difference of opinion as to the compass of a species and genus, and even of an order, or of a phylum.

As regards the term "species," the ordinary zoologist applies it to a group of individuals, existing in a state of nature, that he cannot distinguish one from another, by any *constant* characters that are not sexual. The individuals of the group may—leaving sexual characters out of account—differ one from another in little points; but if the amount of difference be so fluctuating and inconstant that it cannot be readily and precisely defined, or if it can be shown to depend upon certain periodically-recurring or seasonal conditions,

then all such individuals are regarded as forming one "*species.*"

The final test of species, of course, is the power of the individuals composing it to reproduce freely, *inter se*, fertile offspring of their own kind. This test can rarely be applied, although there are some entomologists who appear to think that inferences drawn from the minute pattern of the dried reproductive organs may be used with absolute confidence as a sufficient substitute for it. In the higher animals certain biochemical tests are also, no doubt, final—*e.g.*, the blood-reaction of the individuals of the species *inter se.*

Though the individuals of a species resemble one another very closely, they are not all *exactly alike* in every minute detail; more or less they tend to *vary*, especially in the case of common species with a wide area of distribution.

If any such variation from the standard of the species have a tendency to recur with any sort of constancy we then have a *variety;* and if there is good evidence that any such variety is peculiar to some particular locality, in which it is more or less isolated, it is looked upon as a *geographical race* or a *subspecies.*

What may be supposed to happen in the case of a plastic species in a state of nature is well paralleled—as the immortal Darwin revealed—by what is known to have happened in the case of certain common domesticated species of animals and plants in the hands of man.

So far we have considered classification from the broad standpoint, as an attempt to follow out pedigree and to reconstruct a genealogical tree. But classification has also to be looked at from the nearer standpoint of the pure systematist, whose main object may be merely to identify species and to tabulate them with extreme precision. In this way we get Classes split into *Subclasses* and *Superorders*, Orders into *Suborders* and *Superfamilies*, Families into *Subfamilies*, and Genera into *Subgenera.*

These divisions are convenient when they emphasise obvious subordinate natural affinities, but they are of little or no value and indeed are often actually misleading when they are based upon the differences seen in some one organ considered by itself. Such "single organ classifications" tend to share the defects of a *physiological classification*—a system

that may unite forms which morphologically and genetically *are not at all closely related, such as, to take extreme instances, the limbless snakes and the lizards, the whales and the fishes.*

II.—Geographical Distribution of Animals.

Every phylum is represented in every great geographical region of the globe, but this is not the case with every Class and Order, still less with the smaller phyletic subdivisions. Man and the animals domestic and parasitic that move in his orbit excepted, each species in a state of nature has its own restricted range, the limits of which though no doubt determined or maintained by conditions at present existing (such as land-configuration, altitude, and climate; enemies, competitors, helpers, and hosts), must have been predetermined and ordained by the physical conditions that obtained in an earlier geological epoch.

On the theory of Evolution the species at present existing in any particular region of the world either (1) must be the descendants of the species that existed there in the geological epoch immediately preceding, or (2) must have immigrated after some period of geological disturbance, or (3) may be an association of aborigines and immigrants.

Considering the subject from the first of these three points of view. Huxley divided the world into four primary zoological provinces, as follows:—

(1) The *Novozelanian Province*, including New Zealand. The only indigenous mammals are some bats and perhaps rats; and there is no evidence that any mammals existed in New Zealand in earlier geological times.

(2) The *Australian Province*, including Australia, Tasmania, and the Negrito Islands. Except for some bats and rats, and perhaps a dog (which, however, may be a prehistoric immigrant of the human period, run wild), the only indigenous mammals are Marsupials and Monotremes; and the mammalian fossil remains of the immediately preceding geological epoch are characteristically and overwhelmingly Marsupial.

(3) The *Austro-Columbian Province*, including South America and North America as far as Mexico. Here,

whether we take the fauna at present existing, or the fossil remains of the geological epoch immediately preceding, we find the same features positive and negative, namely, diverse and abundant *Edentata*; large Rodents; no indigenous oxen, sheep, or antelopes; no *Insectivora*; and no monkeys resembling those that are found in the Old World.

(4) The *Arctogæan Province*, including all the rest of the world, namely, North America, Europe, Asia and most of its large islands, Africa, and Madagascar. In this province there are no Marsupials (except Opossums in North America), and few Edentates; but wild oxen, wild goats and sheep, antelopes and *Equidæ* are characteristic of most parts of it; and although some of its most striking mammals (such as Elephants, Rhinoceroses, and Giraffes) are now found only in its tropical parts, they, at an earlier geological period, were widely distributed in its northern latitudes also.

Considering the subject mainly from the other two points of view, Huxley subdivided Arctogæa into four subprovinces, as follows:—

(a) *America north of Mexico.* Here Elephants, Rhinoceroses, and Equidæ (except such as have run wild comparatively recently) are absent from the existing fauna and are known only in the fossil state.

(b) *Africa south of the Sahara.* Here those elements of the Arctogæan fauna, which in northern latitudes disappeared during the glacial period, still survive, probably as immigrants from the north.

(c) "*Hindustan.*" Here in the same way, probably, as in Africa, most of the elements of the Arctogæan fauna survive, but Giraffes are known only in the fossil state.

(d) *Europe, Northern Africa, and Asia north of the tropic.* Here Elephants, Rhinoceroses, and Giraffes (Europe) are known only in the fossil state, Elephants also in the subfossil state (Siberia).

Unfortunately Huxley's illuminating scheme is not so commonly adopted as the more empirical schemes of Sclater and Wallace, by which the world is partitioned entirely in accordance with the distribution of existing species into the following zoogeographical regions:—

(1) *Palæarctic Region*) παλαιός = old; ἄρκτος = the North),

including Europe and the adjoining islands; Africa north of the Sahara; and the whole of Asia, except the southern half of Arabia and the mainly tropical parts that lie east of the Indus and south of the Himalayas and Yangtsekiang.

(2) *Ethiopian Region*, including Africa and Arabia south of the tropic of Cancer, as well as Madagascar and the adjacent small islands.

(3) *Oriental or Indian Region*, including the tropical parts of Asia that lie east of the Indus and south of the Himalayas and Yangtsekiang, as well as the great islands of Ceylon, Sumatra, Java, Borneo, and the Philippines.

(4) *Australian Region*, including Australia, New Guinea, Celebes, and the smaller interjacent islands, as well as New Zealand and Polynesia.

(5) *Neotropical Region*, including South America, Southern Mexico and Central America, and the West Indies—corresponding with Huxley's Austro-Columbian Province.

(6) *Nearctic Region*, including North America north of the tropic.

III.—The Phylum Arthropoda and its Position.

The Arthropoda are defined as animals that are composed of a series of segments, and that possess jointed appendages and a firm cuticle or exoskeleton. They are most nearly related to the *Annelida*, or Segmented Worms, and have even been classified in one group with them. They resemble the *Annelida* in the segmentation of the body, in the paired appendages, in the form and position of the nervous system, and in the position of the heart; but they differ from the *Annelida*—to consider obvious superficial characters only—in having the appendages segmented, in having at least one pair of appendages modified to form jaws, and in having a firm exoskeleton connected with an elaborate system of striated muscles. There is, indeed, one small group of Arthropoda—the *Onychophora*, of which the extraordinary *Peripatus* is the type—in which, besides certain other striking Annelidan features, the cuticle is soft and the body-wall is a simple tube of unstriped muscle; so that we have in this group an undoubted link between the two phyla.

All the segments of an Arthropod are formed on one plan, though that plan is subject to a good deal of modification. The simplest form of segment is a ring, composed of a dorsal arc, or *notum* (νῶτον=back), and a ventral arc, or *sternum* (στέρνον=breast); between the notum and sternum there may be two side pieces or *pleura* (πλευρόν=flank). The pleura are sometimes quite inconspicuous, as in the abdomen of an insect; sometimes large and complex, as in the thorax of many insects.

Between the segments, when they are not modified by fusion, the cuticle remains soft, to give freedom of movement.

The "typical" segment carries a pair of appendages which are articulated near the junction of the sternum with the pleuron on either side.

In all Arthropoda, except a few degraded parasites in which *all* traces of segmentation are lost, the anterior segments are indistinguishably united to form a head, and their appendages are modified, wholly or partly, for dealing with food, and for sensory purposes.

Behind the head the segments and appendages may be all alike, or nearly so, as for instance in Centipedes; or the segments may, to a varying extent, be fused together, and their appendages diversely modified and some of them suppressed altogether, as for instance, in a crab, or a scorpion, or an insect.

The cuticle of Arthropoda consists largely of a tough substance called chitin (χιτών = a coat of mail), and is sometimes further strengthened by calcareous deposit. Chitin is extremely resistant; it withstands the action of strong acids and alkalis, and is decomposed only by prolonged maceration.

The outer layer of the cuticle is moulted periodically *en masse*, either throughout the whole life of the animal, or during the pre-adult stages of growth. For some little time after each moult the cuticle is soft, but it gradually becomes hard again.

This chitinous cuticle is not a true skin like the epidermis of vertebrate animals, since it is not composed of cells but is merely a secretion of the epidermis. The same

remark applies to the "hairs," "bristles," "spines," and "scales" that clothe or fortify the bodies of many Arthropoda: all these are merely hollow outgrowths of the chitinous cuticle secreted by processes of epidermic cells; but so long as this fact is not forgotten there can be no impropriety in calling them "hairs" and so forth. Even those who use the terms *seta* (Lat. *seta* = bristle) and *chæta* (χαίτη = hair) for the hairs and bristles, have no other name than "scales" for the broad flat setæ of the wings of butterflies and mosquitoes.

Not only does the cuticle form an exoskeleton, but it also sends processes inwards to form the tendons of the muscles, the lining of certain parts of the alimentary canal and genital ducts, the inner layer of the air-tubes (tracheæ) when these exist, and other internal supports.

The digestive, respiratory, excretory, and reproductive systems differ in the different classes of Arthropoda, but the vascular and nervous systems have a general unity and constancy throughout the phylum. One general fact about the digestive system must, however, be noted; namely, that in all normal Arthropods certain paired appendages near the mouth are differentiated, wholly or partly, to form jaws or foot-jaws.

The body-cavity contains blood, and so forms part of the vascular system; but a heart and blood-vessels are usually present.

The heart is dorsal in position and is enclosed, more or less completely, in a pericardium; it has no *directly* afferent vessels, but is filled from the pericardial cavity, the blood passing through valvular slits in the heart-wall.

The blood-vessels vary in degree of development. In many Arthropods the circulation is more or less lacunar, the blood being driven from the heart, by a few short efferent vessels, into the tissues, whence it passes, either by distinct vessels or by mere vague afferent currents, to the pericardial cavity, and so back to the heart again. In some Arthropods, however, particularly, though not exclusively, in certain larger forms that breathe by gills, there are well-developed arteries and veins which may even be connected by capillaries.

The blood is usually colourless, but in some Arthropods

the plasma is greenish or bluish, and in a few the plasma is red from dissolved hæmoglobin.

The heart can be seen in action, with a minimum of trouble, by watching a "blood-worm" (larva of *Chironomus*, p. 121) under the microscope.

The central nervous system consists of (1) a large supra-œsophageal ganglion or brain, lying dorsally in the fore part of the head, and (2) a chain of ganglia extending ventrally along the body. The brain and the foremost (subœsophageal) ganglion are connected by a pair of commissures which embrace the gullet like a collar. In Arthropods, such as Centipedes and insect-larvæ, where the segments behind the head are all much alike, the ventral chain is simple and regular, with a ganglion for every segment; but in crabs and many flies the ventral ganglia are concentrated in the thorax; and between these extremes there are many gradations.

The nervous system can be seen, with a minimum of trouble, in any transparent aquatic insect-larva; it is particularly easily seen in the larva of *Simulium* (Fig. 31).

The senses of Arthropoda are highly developed. The antennæ are not only—like the appendages—organs of touch, but are also organs of special sense, particularly of smell. Special hairs near the mouth and on the mouth-parts and their palps may possibly be organs of taste, since many Arthropods show strong predilections in the matter of food. Undoubted sound-conducting organs, besides mere vibratile (auditory) hairs, are present in certain insects (organs for the *production* of sound being extremely common). The eyes of Arthropods are of two kinds—simple eyes, or *ocelli* (Lat. *ocellus* = a little eye), and compound or faceted eyes—both kinds often being present in the same individual. Both kinds of eyes are composed of special translucent, refractive, perceptive, and pigmentary elements. The simple eye, or ocellus, consists of an epidermal pit, or cup, of cells lying below a cuticular cornea-lens. The cells of the bottom of the cup form a retina, the transparent ends of the cells of the sides of the cup form a vitreous body, and the cells of the edge of the cup are pigmented to form a sort of diaphragm.

The compound eye consists essentially of a group of tiny ocelli of a peculiar kind, known as *ommatidia* (ὀμματίδιον = a diminutive eye), each of which is structurally complete in itself and morphologically independent, though functionally they all act together as a single organ. The number of ommatidia in a compound eye varies; it is said in the case of the house-fly to be 4000, and in the case of a dragon-fly to be 20,000. Compound eyes are present by no means in all Arthropoda, but are not found outside this phylum.

The Arthropoda are usually divided into five great Classes according to the style of their segmentation, the number and general disposition of their appendages, and the nature of their breathing-apparatus, namely: *Crustacea*, *Prototracheata*, *Myriapoda*, *Insecta*, and *Arachnida*.

The *Crustacea* are, for the most part, aquatic, and breathe by gills. The segments of the body are usually arranged in three regions—head, thorax, and abdomen—with the separation between the head and thorax quite obscure. There are two pairs of antennæ, and of the numerous other appendages some are biramous.

The *Prototracheata* (or *Onychophora*) are terrestrial Arthropods breathing by tracheæ (p. 27), which are diffuse. The individual segments of the body are superficially obscure, the body being soft and worm-like. The head is not demarcated from the body, and its appendages are a pair of antennæ, a single pair of jaws, and a pair of oral papillæ. The appendages behind the head are numerous and all alike stumpy. This class includes one genus, *Peripatus*, the species of which are found in parts of the Ethiopian, Oriental, Australian, and Neotropical regions. They have some resemblance to a slug, and also some resemblance to a caterpillar; they live in rotting timber or under stones, and avoid the light, so that they are rarely seen. Though they are of the greatest interest zoologically, as being intermediate between Arthropods and Annelids, they are of no concern from a medical standpoint and so cannot be noticed further here.

The *Myriapoda* are terrestrial Arthropods breathing by tracheæ, which have a definite arrangement. The segments and appendages behind the head are for the most part alike. There is one pair of antennæ.

The *Insecta* are for the most part terrestrial and aerial Arthropods, and they breathe by definitely-arranged tracheæ. The segments of the body, in the adult, are disposed in three very well-defined regions—head, thorax, and abdomen. The first pair of appendages are antennæ, and the thorax carries three pairs of legs, and usually, in the adult, two pairs of wings.

The *Arachnida* are, for the most part, terrestrial Arthropods, and the majority of them breathe air, sometimes by definitely-arranged tracheæ, sometimes by other means. The grouping of the segments of the body is not constant, but commonly two regions—cephalothorax and abdomen—can be recognised. The appendages never exceed six pairs, of which four pairs are legs. There are no antennæ.

In classical text-books the Arthropoda are treated with some regard to phyletic precedence, either in the order given above, or—as seems neater—with the *Arachnida* immediately following the *Crustacea*.

It is generally allowed that the *Crustacea* should take the lowest room. For although some of the highest developments of the Class (such as the Land-crabs) are, when viewed with our ethically-tinged spectacles, as nobly organised and as "intelligent" as any Arthropod except an Ant, yet the morphological level of the class as a whole lies lower than that of the typical insect. At any rate they stand farthest back in the distant geological retrospect: numerous fossil Crustacea have been found, among the very oldest remains of undoubted animal nature, in the Cambrian rocks; and Crustacean remains are quite abundant in the later Silurian system, where Arachnida (Scorpions and *Eurypterus*), Myriapoda, and Insecta (Cockroaches) first make an appearance.

The *Arachnida* stand clear of the others, but seem to be closer to the Crustacea than to any of the other classes.

The *Myriapoda* and *Insecta* and possibly *Peripatus* stand together, and apart from the other two classes. Some zoologists even include the Centipedes in one class with the Insects.

In this book, however, we propose to forget phylogeny, and to deal with Arthropoda in quite an abnormal way, and according to a sort of pathological warrant of precedence, in

the following order:—Insecta, Arachnida, Myriapoda, and Crustacea, leaving the Prototracheata out of account altogether for reasons already explained.

IV.—Arthropoda in their General Relation to Human Pathology.

Ever since the days when Aaron stretched forth his rod and smote the land of Egypt with lice and flies, the Arthropoda—whatever else may be said of them—have had an evil reputation as the source of some of the sharpest and readiest scourges of mankind.

At first treated merely with disdain or disgust, as pertinacious aggressors or as simple parasites, the species that commonly annoy man are now, as a result of a series of discoveries brilliantly initiated by Manson in 1879, looked at in a much more serious way; indeed, the present tendency is to go to the other extreme, and to regard them all as vested with lethal powers over man and beast.

This introductory chapter cannot therefore be concluded until the question of Arthropod parasites and carriers of disease has been briefly looked at from the purely biological standpoint.

(a) *Parasitism; and Parasitic Arthropods.*

The term parasite (παράσιτος = one who lives at another's expense) has been used almost as loosely as the adverbs "awfully" and "absolutely." Some apply it indiscriminately to any animal that commonly associates with other species. Others, with more approach to exactness, apply it to any animal that can and commonly does live by extracting nutriment from the tissues of other living animals. Others, still more precise, restrict the term to an animal that is specially modified, or *adapted*, for obtaining its nutriment solely from the body of some other living animal, generally to the detriment of the latter.

To form a just conception of the term parasite the two factors of association and offence must be considered separately.

As regards association: Two animals of different kinds

may always be found in company without, so far as can be seen, influencing each other either for good or ill. Thus certain small shrimp-like Crustacea of the genus *Spongicola* are always found caged within living Basket-sponges. Or two animals of different kinds may always be found associated, one of them getting obvious benefit, without, so far as can be seen, either benefiting or incommoding the other. Thus the small soft defenceless crabs of the genus *Pinnoteres* always use the mantle-chamber of living Oysters and Mussels as a fortress and refuge. Or two animals of different kinds may live together for obvious mutual advantage. Thus a Hermit-crab, *Paguropsis typica*, always carries—and carries in a particular manner—a particular species of sea-anemone on its back, using the sea-anemone as a blanket, which it can pull on and off as it likes, and in return giving the sea-anemone carriage to fresh pastures. Thus the mere fact of association does not by itself imply parasitism, and this is recognised by applying the term *commensalism* to such cases as these.

On the other hand one kind of animal may associate with another, with the obvious intention (so far as the apparently purposive actions of Arthropoda imply deliberation) of getting what it can, regardless of any annoyance or injury that it may incidentally inflict, but not to gratify any imperative predatory instinct. Thus the house-fly and blow-fly all the world over live in and around human dwellings, and may in some circumstances be harmless or even actually useful to their human hosts, though in most circumstances they are objectionable and detrimental.

Such a doubtful messmate as a blow-fly or a bluebottle may perhaps treat a live man as if he were dead: it may casually lay its eggs in the nostrils of a helpless or incompetent human being, and the maggots may live on the tissues of the human being, quite like parasites. Here we see how an almost innocent commensalism may pave the way for parasitism.

Next as regards the factor of aggression: An animal that can support life quite well on the sweet juices of plants may take to sucking the blood of other animals. This is the case

with the female *Culicidæ.* Many Culicidæ—as on small tropical islands—may seldom get a chance of sucking blood; others such as *Stegomyia fasciata*, which is so constantly associated with man, in tropical latitudes, as to be known as a house-mosquito, may make a habit of it. Here we see a more or less predatory insect becoming commensal like a house-fly, and thus illustrating both aspects of parasitism.

The bed-bugs belong to an Order which includes a large number of predatory species: the ticks belong to a Class which is pre-eminently predaceous: hardly any modification of the structure and habits of these two groups of animals is necessary to convert them into parasites, without any bias from association. Here we have an instance of a predatory parasite that does not always form a fixed and constant association with any particular kind of animal.

From loose parasites of this kind we pass to parasites like lice (*Siphunculata*), which are definitely associated with animals of a certain kind—mammals. Here the whole organisation is profoundly modified in the way of adaptation to the particular mode of life. Wings are absent; legs are converted into grapnels for clinging to hair; the mouth-parts form a long suctorial tube, which can be firmly anchored in the host's skin; the eggs are firmly attached to the host's hairs; and metamorphosis is suppressed, so that the young louse when it leaves the egg is a finished parasite like its parents.

The few instances selected above are quite sufficient to show that there is no clear line of separation either between commensalism and parasitism, or between piracy and parasitism; but that we can pass by easy gradations and many circuits from innocent casual attachments and chance predatory onslaughts to those definite associations of two different species, for the benefit of one of them and to the detriment of the other, which constitute true parasitism.

(b) *Arthropoda as "Carriers" of Disease.*

(1) The term "carrier" has been used almost as loosely as the term parasite, the looseness indeed being inherent in the

subject. Some apply it indiscriminately to any animal that, getting in any way contaminated with pathogenic micro-organisms of any kind transports them in any manner to a suitable station. In this view a house-fly that casually settles on a baby's eyelid after casually crawling on pus is a "carrier."

(2) Others would restrict the term so as to include only cases where the micro-organism is actually ingested by the insect, multiplies by fission in its gut, and is passed with undiminished virulence in its secretions or its excreta. In this view a house-fly that casually swallows typhoid bacilli, and afterwards casually voids them increased in number into milk or on to food is a "carrier."

(3) Others again would restrict the term still further, so as to include only cases where a specific micro-organism is ingested by a blood-sucking Arthropod, from which, after proliferation, its progeny are expelled in such a way that when the said Arthropod bites again, the wound that it inflicts may somehow become specifically infected. In this view a flea that has become infected from a plague patient is a carrier of the plague bacillus.

(4) Still others restrict the term to those cases where there is a fixed and constant relation between a specific parasitic micro-organism and a specific blood-sucking Arthropod. In these cases the specific micro-organism after being ingested resides for a definite period in the specific Arthropod (or one of several closely-related species), proliferates in a definite and distinctive manner in some part of the Arthropod's gut, and ultimately colonises in a distinctive manner a definite part or tissue (usually the mouth-parts or salivary glands) of the Arthropod; so that when, after the lapse of a definite term, the said Arthropod bites another customary victim, it perforce in the act of biting transfers some of these colonists to a new host. The infection thus "carried" by the Arthropod may expire with the life of the individual Arthropod, or may be transmitted through its eggs and larval stages to the following generation.

It is for such cases, where a particular kind of blood-sucking Arthropod is definitely utilised by a specific micro-

parasite as a means at once of fructification, and of dispersal that is both ample and exact, that the biological idea of a carrier should be reserved.

Still it is evident that no hard-and-fast line of separation can be drawn between such a fixed and constant engine of distribution, and a casual and uncontrived general-carrier such as a fly.

If at the first blush there seems to be something entirely strange and new, not so much in the fact that a blood-sucking insect can imbibe a parasitic animalcule from one individual victim in one shape and can inject it into another individual victim in another shape, as in the fact that the very existence of the said parasitic animalcule as a species depends upon this roundabout and precarious process, it has to be remembered that the component features of the phenomenon are by no means isolated or unique.

It is a familiar experience, for instance, that lowly organisms of many kinds may often score a point in the internecine struggle for existence, by that extreme form of passive resistance known in popular language as going to bed, or in technical language as encystment. Safe in its shell it lets the world slip, as the Baron of Sheppey in the Ingoldsby Legend treated the Sheriff of Kent and his posse.

Again, it is a familiar experience that an encysted organism may merely remain latent until its opportunity arrives; like the spore of a bacillus, like an encysted amœba, or like the gemmule of a Sponge or the statoblast of a Polyzoon. Or it may mechanically adhere to some other active animal and itself remaining inert, may be transported to some happy hunting-ground where it resumes the ordinary tenour of its life; as the quiescent "Hypopus" of certain mites is transported by flying insects, or as the gemmule of a sponge may be transported by birds. Or a paired and encysted *couple* may, within the wall of its cyst, break up into a multitude of independent particles, like an encysted Gregarinid or Coccidiid; each of the latent units being ever ready, when liberated from confinement,

> "To take occasion by the hand
> And grasp the skirts of happy chance."

By compounding these different phenomena we get some broad idea of the normal methods of self-preservation that are open to any species of microparasite whose natural habitat is the living blood of a vertebrate animal, provided that other busy blood-sucking parasites are at work on the outside.

The rôle of the intermediate "carrier" host makes such an impression on the imagination that we are apt to forget that even when the adaptation between microparasite, intermediate (carrier) host, and final or destined host is perfected, there must be many failures and hitches. A given microparasite must often get into the stomach of the wrong blood-sucking parasite and be digested. A given blood-sucker must often inject the spores of a microparasite into the wrong final host, where they perish. Perhaps the failures may be more numerous than the successes, but this is allowed for by the enormous fertility of the parasite that has to be passively transferred. A cynic has said of man that in every corporate action he finds the right way only after taking every conceivable wrong turning and walking into every pitfall. Probably it is much the same with these adaptive parasites, that in addition to all their other difficulties have to hit a particular bridge from host to host. What appears to the easy-chair scientist as an elegant stream, may be a seething cauldron of eddies and cross-currents. In the language of the poets, chaos lies very close beneath the orderly surface that we love to contemplate as we "mutter the comfortable word 'evolution.'"

V.—Classification of Arthropod Parasites and Carriers that Affect Man.

From the facts sampled in the foregoing section, it is evident that it is by no means easy to define either a parasite or a carrier; so that the following attempt to classify the Arthropoda that are detrimental to the human organism is to be regarded merely as a suggestive artifice.

The species that, whatever else they may do, exert some direct effect upon the tissues of man, may be classified broadly as (*a*) Accidental and Casual Parasites; (*b*) Discretionary

Parasites that are not wholly and manifestly constrained to that mode of life; and (*c*) Unconditioned Parasites that are entirely and obviously dependent on parasitism for their existence.

The species that, whatever other direct effect they may produce, affect the human organism indirectly, by introducing other germs or parasites, may be broadly classified as (*a*) Accidental and Casual Carriers, or Miastors; (*b*) Qualified or Adapted or Specific Carriers, that are essential to the existence of some particular species of endoparasite; and (*c*) Porters, that help in distributing a particular species of endoparasite, but are not essential to its existence.

A. ARTHROPOD PARASITES OF MAN.

(a) *Accidental and Casual Parasites.*

Under this head we may include (i) certain trespassers in the alimentary canal; (ii) certain trespassers in the tissues; and (iii) certain casual blood-suckers.

(i) The larvæ of many kinds of Arthropoda may get into the human intestine, having been swallowed (either as eggs or as larvæ) in food, or having crawled in at some natural orifice. The maggots of *Eristalis* (p. 144), of *Apiochæta* (p. 145), of *Sepsidæ* (p. 147), of several species of *Muscidæ* (p. 153) and *Anthomyidæ* (p. 180), of *Sarcophaga* (p. 179), the larvæ of moths and beetles and mites, and even young centipedes, have been recognised among such intruders; and as for most of them the human intestine is far from being the normal and natural station, they cannot, even though they may do harm, be classed as parasites. It is better to call them *Pseudoparasites.* It must be remembered, however, in the case of *Apiochæta* (p. 145) that the family to which this species belongs (*Phoridæ*) has in all stages a definite charnel-house taint.

(ii) The larvæ of *Sarcophaga* (p. 179) and of several species of *Muscidæ* (p. 149) may get into neglected wounds, or, gaining access by nostril or ear, may undermine the face and burrow into the skull of living persons; and the larvæ of several families of mites (e.g. *Trombidiidæ*, *Tarsonemidæ*, *Tyroglyphidæ*) may burrow into the human epidermis.

These all make themselves quite at home and behave as parasites; but they cannot be styled parasites off-hand, since the position is far from being necessary to the existence of the species. They might, perhaps, be called *Hemiparasites.*

(iii) A considerable number of predatory Arthropods must be looked upon, so far as man is concerned, as quite casual parasites, since they neither make a point of attacking man nor have any predilection for human dwellings. Such are most mosquitoes, midges, the *Simuliidæ*, and *Tabanidæ*, and the Reduviid bugs (p. 207).

(b) *Free or Discretionary Parasites.*

Under this head we may collect a considerable number of active predaceous species that habitually live and breed only in human dwellings and outhouses or their vicinity, and either habitually or frequently suck the blood of man. Among such are several species of mosquitoes (e.g. *Culex fatigans*, *Stegomyia fasciata*), the maggot of *Auchmeromyia* (p. 154), several of the blood-sucking Muscidæ (e.g. *Stomoxys*, *Hæmatobia*), and the bed-bugs.

It is doubtful whether *Glossina* and the maggot of *Cordylobia* (p. 155) should be included here; since, though neither of these shows any adaptive structural differences from its own nearest relatives, yet it is said that *Glossina* cannot support life on anything but living vertebrate blood, and that the maggot of *Cordylobia* can live only in the subcutaneous tissue of a living mammal. Both *Glossina* and *Cordylobia*, so far as habits go, ought perhaps to be included among the unconditioned parasites.

(c) *Unconditioned or Adapted Parasites.*

Here we must class all those species that not only feed upon human blood and lymph, but also are in some special way modified for clinging to, or sticking to, or burrowing in a host; such as the blood-sucking lice (p. 212), the fleas, the ticks, the itch-mites, the *Demodicidæ* (p. 268), the *Pentastomida*, and the maggot of *Dermatobia* (p. 182).

The *Hippoboscidæ* (p. 185) belong to the class of adapted or unconditioned parasites, but they do not, except fortuitously, attack man.

As already noticed, *Glossina* and *Cordylobia*, though they are not specially modified for intimate and permanent contact with their host, must be reckoned as parasites positive.

B. ARTHROPOD "CARRIERS" THAT AFFECT MAN.

(a) *Accidental and Casual Carriers: Miastors.*

Here, first of all, should be placed flies, like the common house-fly, which in ways that are mainly mechanical (see p. 32) may spread abroad any kind of hardy pathogenic germs, but are not fixed and necessary agents for the distribution of the germs of any particular species.

Any kind of predatory Arthropod that habitually attacks man is a potential carrier of this sort, as also is any omnivorous domestic insect (cockroach, ant, etc.) that may pollute provisions.

Carriers of this kind may be called *Miastors* (μιάστωρ = a carrier of pollution).

(b) *Qualified or Adapted Carriers.*

An adapted carrier—commonly known as an "intermediate host"—is a species, parasitic or not, that serves, at the very least, as a specific vessel for carrying a specific parasite on a definite course between two specific points. Among such carriers we meet with several shades of definition:—

(i) Carriers like *Cyclops* (p. 313), in which the embryo of the specific parasite, as it swims free in water, is cribbed, cabined, and confined. If the *Cyclops* with its inside passenger be swallowed by the right species (Man), the *Cyclops* is digested and the passenger thus liberated to follow its destination as a parasite of the human host.

(ii) Carriers like certain species of *Culex*, *Stegomyia*, *Mansonia*, *Anopheles*, *Phlebotomus*, and *Glossina*; perhaps also *Cimex* and *Conorhinus*; that in satisfying their thirst for blood imbibe a specific blood-parasite from one victim, and after a definite period (during which the parasite takes advantage of the opportunity to be fruitful and multiply) inject it into the blood of another victim of the same susceptible species.

(iii) Carriers like some *Glossinæ*, that may take a specific

parasite from the blood of one of numerous species of vertebrate animals in which the said parasite is naturalised and innocuous, and may (after a definite period during which the parasite multiplies) inject it into the blood of some alien species of vertebrate to which it is fatal.[1] Carriers of this kind are the most dangerous of all, as it is impossible to control all the original sources of their infection.

(iv) Carriers like the ticks (and possibly[1] *Stegomyia fasciata* sometimes, in "carrying" the germ of yellow fever). Here the carrier imbibes a specific parasite in the blood of a victim and transmits it through egg, or larva, or nymph (see p. 274), so that the tick in an after stage becomes infective. Carriers of this kind are more than ordinary dangerous, since the infection may remain latent for many months, during which the infected eggs and larvæ may be carried mechanically to an enormous distance.

It is best to restrict the term Carrier to these forms that are necessary for the maintenance of any species of endoparasite.

(c) *Porters.*

Carriers of this kind are, roughly speaking, intermediate between Casual Carriers and Adapted Carriers; they render definite assistance in distributing a specific microparasite, but are not essential to its existence.

Here are included certain common species of fleas (p. 190) that imbibe the specific plague-bacillus from the blood of one of several species of susceptible vertebrate animals, but do not digest the bacilli, which pass away in the excreta of the insect. When the flea, thus infective, resorts to another susceptible vertebrate to feed again, it somehow or other—probably by its excreta, which are freely expelled during the act of sucking blood—infects the wounds that it inflicts on its new host. There seems to be here no definite adaptation of the bacillus to the flea, or *vice versâ;* and there seems to be no doubt that though fleas very materially aid the dispersal of the bacillus, the bacillus can be disseminated in many other ways.

[1] This, of course, is *not* to be understood as being the *usual* way in which, in the case of man, *Glossina* and *Stegomyia* spread their specific infections.

CHAPTER II

The Class Insecta, and the Order Diptera

Class INSECTA.

IT is not germane to the purpose of this work to attempt to discuss the importance of insects either in the economy of Nature at large or in their manifold bearings upon human affairs; it is sufficient to say that insects outnumber all other species of animals put together, that it is impossible to overestimate their natural influence and momentum, and that so far as their relation to civilised man is concerned, insects have in various ways retarded his most resolute efforts to replenish the earth, and have at times and in places disputed his very dominion.

Among Arthropoda the typical adult insect is distinguished by the form of the body, the number and disposition of the appendages, and the possession of wings.

The body consists of three well-defined regions or *syntagmata*—head, thorax, and abdomen.

The head is a chitinous capsule, sharply differentiated from the thorax; except as indicated by the paired appendages, it shows, as usual, no trace of segmentation; nor does the number of paired appendages reveal its true segmental composition. The thorax is composed of three segments—the prothorax, mesothorax, and metathorax. The prothorax is often distinct, as also, in insects that do not fly much, are the other two segments; but in insects whose ordinary method of locomotion is flight, the mesothorax and metathorax at least are fused together to increase the leverage of the wings. In the abdomen, which is generally well demarcated from the thorax, the individual

segments are, as a rule, quite distinct, and they often overlap one another; the number of abdominal segments is not constant, the maximum in any adult insect is 10, but in most insects it is much fewer than this. In insects with very few visible abdominal segments it is often the case that several terminal segments are modified to form an ovipositor, which, when it is not in use, is usually invaginated and invisible.

The Head and its Appendages.—The head contains, besides appropriate muscles, the supra-œsophageal ganglion, or brain, and the pharynx; its appanages and its true appendages are sensory and feeding organs.

At the sides of the head are the eyes; on the under-surface is the mouth, flanked by the mouth-appendages, or *trophi;* above the mouth, extending across the face, is the *clypeus;* the upper part of the head is the *front*, or *epicranium;* the back of the head, abutting on the thorax, is the *occiput;* in elongate heads the ventral area behind the mouth is known as the *gule.*

The *appanages* of the head, as distinguished from the true paired appendages, are the following:—

(1) Depending or projecting from the free edge of the clypeus is the *labrum*, or upper lip, a sort of eave overhanging the mouth; in many insects that prick and suck, the labrum is produced to form (2) a long style known as the *epipharynx;* (3) in the floor of the mouth is a process on which the salivary ducts open; this when it is soft is known as the *tongue*, but when it is produced far beyond the mouth, as it is in flies, is called the *hypopharynx;* the other appanages of the head are (4) the lateral eyes and the ocelli. The lateral eyes are generally compound and faceted, but they may be non-faceted, or they may be absent altogether; the ocelli or simple eyes, when present, are usually three in number, and stand in a triangle on the crown of the head; but sometimes there are only two ocelli.

The *true appendages* of the head are the antennæ and three pairs of jaws. The *antennæ* are generally placed between the eyes; though commonly elongate, flexible, and many-segmented, they vary greatly in details of

structure, and may even differ in the sexes of the same species; their functions are tactile, olfactory, and sometimes, it is supposed, auditory.

The three pairs of mouth-appendages or "jaws" are, in successive order, *mandibles*, *1st maxillæ*, and *2nd maxillæ* or *labium*. Their individual structure varies very greatly throughout the class in adaptation to different modes of life and different kinds of food; all that need be said, at the present moment, is that both pairs of maxillæ commonly carry each a pair of segmented *palps*, but that the mandibles never do; that the 2nd pair of maxillæ are either more or less fused together below and behind the mouth to form a lower lip or *labium*, or may be modified to form a sheath for the other mouth-parts; and that the mandibles, or the 1st maxillæ, or both of these, may be vestigial or absent; indeed, in some short-lived insects that do not feed in the adult state, all the mouth-parts may be reduced to vestiges.

The Thorax and its Appendages.—The thorax is the locomotor region of the body, and is mainly filled with the muscles that move the legs and wings; it also contains the salivary glands and some of the largest ganglia of the ventral nerve-cord, and gives passage to the gullet. Its three constituent segments are not always easy to distinguish one from another in insects of powerful flight, and this is particularly the case with their lateral pieces or pleura. In some wingless insects the posterior segments of the thorax are not very sharply defined from the abdomen. In the large order of *Hymenoptera*, where the ants and bees and wasps belong, the first abdominal segment is more or less intimately united with the thorax.

The *appanages* of the thorax are the *wings*. In the typical adult insect there are two pairs of these, one pair attached to the mesothorax, the other to the metathorax; but in the true flies (*Diptera*) only the anterior (mesothoracic) pair are present, and there are numerous insects of simple organisation, and many insects adapted to particular conditions of life, that have no wings at all either in one sex or in both sexes. The wings are outgrowths of the integument, stiffened and supported by a framework of *nervures*

or *veins;* these are tubes of chitin containing air, and in their developmental stages, blood. The functional hardened wing is practically a plate of chitin. The form, density, pose, clothing, and folding of the wings show great diversity throughout the class, and furnish characters of systematic importance.

The true appendages of the thorax are the *legs*, of which, in the adult insect, there are typically three pairs, one pair on each segment. Each leg commonly consists of the following successive parts: the *coxa*, which is articulated to the thorax; the *trochanter*, which is usually short; the *femur* and the *tibia*, both of which are usually long; the *tarsus*, which generally consists of several separate pieces, often five, but sometimes fewer. The last tarsal segment commonly ends in a pair of *claws*, but sometimes in a single claw. The form and character of the legs show great diversity in adaptation to different functions—running, hopping, swimming, clinging, digging, seizing and holding prey, collecting and carrying food, etc. There are insects in which some of the legs are reduced in size and useless for locomotion, or with some of the segments of the legs absent. Rarely are legs altogether wanting.

The abdomen contains the stomach and intestine, the excretory tubules, and the reproductive organs. Stumpy legs (*pseudopods*) are present on some of the abdominal segments of certain larvæ; but in the adult insect this region is destitute of true appendages, though the caudal filaments (*anal cerci*) and parts of the ovipositors and stings of certain insects are regarded as homologous with appendages. The abdomen of many *Hymenoptera* is peculiar in often being constricted or even petiolated at its junction with the thorax, and in being something less than an abdomen, since the segment in front of the constriction is united with—and appears to be part of—the thorax.

The alimentary canal runs through the body and opens posteriorly in the last visible abdominal segment; its structure varies according to the food it has to deal with. In most insects that suck liquid food the pharynx, by the contraction of muscles attached to its outer wall, acts as a suction pump, and the œsophagus is provided with crops or food-reservoirs.

The salivary glands open on the hypopharynx, which in some blood-sucking insects is produced into a long slender tube, so that its secretion can be injected into the wound made by the mouth-organs. With the alimentary canal may be mentioned the long slender excretory tubes—*Malpighian tubules*—of varying number, which usually open into the intestine just behind the stomach.

The Respiratory System.—Breathing is carried on by a system of air-tubes, or *tracheæ*, which, except in some larvæ, open at regular intervals on the sides of the thorax and abdomen. The openings are known as *stigmata*, or *spiracles*, and there are commonly ten pairs of them (but often less), namely, two larger pairs on the thorax, and eight smaller pairs on the anterior abdominal segments. The spiracles may be opened and closed by muscles or valves. From the spiracles short wide tracheæ pass inwards and, after branching, break up into copious minute ramifications which carry air to every part of the body. The main tracheal branches almost always unite to form a pair of tracheal mains that run longitudinally on either side of the body, communicating with one another by transverse branches. The larger tracheal tubes are kept from collapsing by a discontinuous thread of chitin coiled in a tight spiral. In many aquatic larvæ the tracheal system is "closed" (*i.e.* does not communicate with the exterior), and breathing is then carried on either through the skin, or through feathery or leaf-like processes which are prolific in tracheæ and are known as *tracheal gills* (Figs. 117, 118).

Reproduction.—The sexes are separate, but *parthenogenesis* (παρθένος = virgin; γένεσις = manner of birth), or reproduction by unfertilised eggs, is very common.

The ducts of the generative glands open at the posterior end of the abdomen. In the female the vagina is often connected (1) with *glands* whose secretion either causes the eggs to cohere in masses, or envelops them in a definite capsule or nest; and (2) with *spermathecæ*, or chambers where, after copulation, spermatozoa are stored for the postponed fertilisation of the eggs. In the male the vas deferens usually expands into a vesicle where the spermatozoa accumulate, and the ejaculatory duct is protrusible. Often

the female is furnished with an *ovipositor*, and the male with paired hooks or *claspers* (Fig. 23).

The egg as a rule is large, and contains much food-yolk. In a few insects the egg is hatched within the mother, and the young is born as a larva; but as a rule the eggs are laid as such—singly, or in masses, or in capsules; sometimes haphazard, but often in an instinctively chosen place on or near food suitable for the larva. There are many insects, again, whose instincts lead them to make for their larvæ housing and nursing arrangements that look like the outcome of protracted foresight.

It is quite exceptional for the new-hatched young to be like the parent: such is the case only with some wingless insects. The young is usually a larva (often with no resemblance to the adult) which passes through a prolonged term of post-embryonic development, or *metamorphosis*, before it becomes adult.

Metamorphosis.—The post-embryonic changes, or metamorphoses, may be gradual or abrupt. Gradual metamorphosis is known as *Hemimetabolous* or "*Incomplete*" *Metamorphosis.* Here the larva is recognisably like the adult, and differs from it, to external view, chiefly in having no wings, and perhaps a larger head and shorter antennæ. In the course of growth the young insect periodically moults, and at each moult it appears a little more like the adult, until at last the wings are fully formed and sexual maturity is attained. The wings in this case first appear as external buds, and when these rudiments are fairly advanced the larva is sometimes spoken of as a *nymph.*

Abrupt metamorphosis is known as *Holometabolous* or "*Complete*" *Metamorphosis.* Here the larva (Lat. *larva* = mask) is often utterly unlike its parents, differing from them not only in the proportions of the body and the absence of wings, but also perhaps in the whole manner of life; the food may be of a different kind, and consequently the mouth-parts may be of an entirely different type. The larva eats voraciously, puts on fat, grows and moults, until it has reached its full size (or exhausted its food-supplies), when it ceases to feed and becomes more or less quiescent. The dormant insect is now a pupa (Lat. *pupa* = a puppet or

doll), and it may be quite inert or it may (as in the case of the mosquito-pupa) be able to move freely. Sometimes the pupa is merely enclosed in a thin pellicle; in other cases it secretes a chitinous exudation, which becomes hard and daık and binds all its appendages together, and it is then known as a *chrysalis* (χρυσαλλις = the metallic golden skin of the butterfly's pupa); or the pupa may lie in its cast-off larval skin, which becomes firm and dark and forms a protective chamber or *puparium;* or the pupa may be enclosed in a silky *cocoon* spun by the larva just before it became quiescent. The dormant stage ends suddenly when the development is complete, the insect splitting its pupal skin and breaking out of its puparium or cocoon as a sexually mature *imago*, to fly abroad as soon as it has shaken out its wings. In this "complete" metamorphosis the larval stage is the stage of feeding and growth: very often it is the longest of the three stages; in some cases it lasts for years. The imago stage is the stage of reproduction, and is commonly, though by no means always, of short duration: in some extreme cases it endures no longer than a day. Though the phases of "complete" metamorphosis appear to be abrupt, they are not always really so; the *internal* rudiments even of the wings can often be made out in the larva by simple dissection.

The adult insect, or *imago*, is typically aerial; but there are many beetles and bugs and even some Orthoptera and Hymenoptera that live in water, and there is one genus of bugs (*Halobates*) that is found only on the surface of the open sea. Again, there are many insects, aerial in the adult stage, the larvæ and pupæ of which are true aquatic animals. Many insects are parasitic on, or in, animals and plants, and the parasitism may be restricted to the larval stage, or to the adult stage, or may involve the whole term of life. Of the external parasites of animals some are merely predaceous, while others are true settled parasites.

Insects are arranged in orders according to the features presented collectively by the wings, mouth-parts, and metamorphosis; and the orders have been grouped by Dr Sharp in four series.

1. *Apterygota* (ἀ privative, and πτερυγωτός = winged).—

True wingless insects, with very slight metamorphosis. Two orders:—*Collembola* and *Thysanura.*

2. *Exopterygota* (ἔξω = outside, and πτερυγωτός).—Winged insects (there are some wingless species in most of the constituent orders, but the types of all the orders are winged); the wings develop *outside* the body: metamorphosis "incomplete," though in the orders with aquatic larvæ the young is often very much unlike the parent. Nine orders:—*Orthoptera, Plecoptera, Psocida* (or *Corrodentia*), *Isoptera, Embiida, Ephemerida, Odonata, Thysanoptera, Rhynchota.*

3. *Endopterygota* (ἔνδον = inside, and πτερυγωτός).—Winged insects (there are some wingless species in most of the orders, but the types of all the orders are winged); the wings start their development as invaginations *inside* the body: metamorphosis "complete." Eight orders:—*Neuroptera, Mecaptera, Trichoptera, Lepidoptera, Coleoptera, Strepsiptera, Diptera, Hymenoptera.*

4. *Anapterygota* (ἀνά in the sense of retrogression, and πτερυγωτός).—Wingless parasitic insects of mammals and birds; probably descended from winged ancestors. A mixed group: it includes the *Siphonaptera*, which are probably related to the Diptera or possibly to the Coleoptera; the *Mallophaga*, which are probably related to the Orthoptera; and the *Anoplura*, which may be related to the Rhynchota.

From our practical point of view, it is permissible to disregard natural affinities and to treat insects in some such order as follows:—

(*a*) Orders which include species that "bite" or sting man, or in some direct way threaten his health:—

1. *Diptera* (Flies)
2. *Siphonaptera* (Fleas)
3. *Anoplura* (Lice)
4. *Rhynchota* (Bugs)
5. *Hymenoptera* (Wasps, Bees)

(*b*) Orders which include species, outside the orders already specified, that damage food, habitations, etc.:—

6. *Coleoptera* (Beetles)
7. *Lepidoptera* (Moths)
8. *Orthoptera* (Cockroaches, etc.)
9. *Isoptera* ("White Ants")
10. *Corrodentia* (Book-lice)
11. *Thysanura* (Fish-insects)

(*c*) Orders which include species, outside the orders already mentioned, that concern the medical officer in some more or less indirect way (*e.g.*, preying upon flies and their larvæ; resemblance to "biting" insects, etc.):—

12. *Plecoptera* (Stone-flies)
13. *Ephemerida* (May-flies)
14. *Mallophaga* (Bird-lice)
15. *Odonata* (Dragon-flies)
16. *Neuroptera* (Ant-lions, etc.)
17. *Mecaptera* (Scorpion-flies)
18. *Trichoptera* (Caddis-flies)

(*d*) Orders of no particular concern to the medical officer:—

19. *Collembola* (Spring-tails)
20. *Embiida*
21. *Thysanoptera*
22. *Strepsiptera*

The orders will be dealt with here in the order of their importance from the medical point of view, beginning with the *Diptera.*

Order DIPTERA (Gr. δίπτερος = with two wings).

Diptera, or Flies, are insects that possess only the anterior pair of wings, which are membranous, and that have the mouth-parts adapted for sucking, and sometimes also for piercing. The hind wings are represented by a pair of club-shaped structures known as *halteres* or balancers. The metamorphosis is complete, and the transformation undergone in the pupal stage sometimes amounts to a complete reconstruction of the body. The head is usually joined to the thorax by a flexible neck that confers very great freedom of movement; the segments of the thorax are combined to form a single mass; and the number of visible abdominal segments is variable, between 4 and 9.

To the medical and sanitary officer Diptera are a group of the very foremost interest, since in addition to being in various ways inimical to health and comfort, certain notorious species are the harbourers, or the intermediate hosts, of microscopic parasites that cause some of the most formidable diseases of tropical countries. Blood-sucking flies, and the profoundly grave part that some of them play in spreading certain specific diseases of man, form an independent subject;

but the ordinary flies that buzz about dwelling-places and outhouses and—since they do not "bite"—are regarded merely as a nuisance, may seriously endanger health in many ways, the most obvious of which may be summarised as follows:—

(1) By carrying pathogenic organisms direct from infected matter upon which they may have settled, to a receptive surface, *e.g.*, a wound, an abrasion, or an absorbent mucous membrane. In this way common flies have been suspected of carrying the microbes of anthrax, ophthalmia, yaws, tropical sore, and perhaps of tubercle, leprosy, plague, and smallpox; and in the case of the first three of these it has been shown by experiment in the laboratory that they are certainly capable of doing so.

(2) By feeding on infected matter and subsequent (retarded) contamination of a receptive surface with their infective excrement, the microbes passing with undiminished virulence through their bodies, and even perhaps multiplying in their gut. In this connection it can at present only be said for certain that the specific bacteria have been found in the intestine or excrement of flies that have swallowed material infected with staphylococcus pyogenes and the bacillus of tuberculosis.

(3) By infecting food or drink in the same direct or indirect manner. In this way there is a mass of evidence, which is corroborated by experiment in the laboratory, that flies may disseminate widely the infection of typhoid fever and cholera and the eggs of parasitic worms; there is a general belief that they convey the infection of infantile diarrhœa; and they have been suspected of having at times something to do with spreading dysentery.

Besides carrying the infections of disease, flies may themselves be the cause of disease in their larval stage. Thus they may lay their eggs in wounds and at the natural orifices of the body, whence the hatched-out maggots may burrow into the tissues and natural passages, and may work even mortal damage. Or their eggs may be laid in or on food, with the result that the larvæ appear in the intestine and give rise to trouble there. Or, in some way or other, their larvæ may find a lodging beneath the apparently unbroken

skin, to set up local inflammation which issues in boils and abscesses.

Most of these dangers from common flies are, of course, most imminent among an ignorant and apathetic population; in slums, and particularly in crowded bazaars where food, offal, and a multitude of afflicted mendicants—in fact, everything that is most attractive to flies—are to be found side by side: such dangers must also be borne in mind in entrenchments and camps, where close observance of the conveniences of civilised life is not always easy. These matters will be more carefully treated when we come to the species of flies which are known, or believed, to be particularly noxious.

It is interesting to remember that the fly-danger seems to have been suspected in the days of Chaucer, as appears in our host's chaff of gentil Roger Coke, of London, in the *Canterbury Tales*:—

> "Of many a pilgrim hastow Cristes curs,
> For of thy persly yet they fare the wors,
> That they han eten with thy stubbel-goos;
> For in thy shoppe is many a flye loos."

As regards blood-sucking flies some of these, as is now well known, are also *aggressively* dangerous as playing a definite part in the maintenance of certain species of pathogenic micro-organisms, among which the most important, so far as man himself is concerned, are the hæmamœbæ of malarial fevers, the trypanosome of sleeping-sickness, certain filarial worm-parasites, and the not yet recognised agent of yellow fever. Blood-sucking flies hardly affect man, though sometimes they may seriously afflict animals, by mere abstraction of blood; but they are responsible for a certain amount of harm by the pain and irritation of their "bites," and by subsequent (septic) aggravation of the bites by scratching.

External Structure of Diptera.

The *head* is commonly hemispherical, the posterior surface or *occiput*, being nearly flat. At its sides are the compound eyes, which with few exceptions are large, encroaching on the vertex, and in males sometimes meeting across the crown.

Between the eyes lie the antennæ. The space between the eyes above the antennæ is the *front;* that between the root of the antennæ and the upper margin of the mouth is the *face;* that behind and below the eye is the *cheek.* In addition to the compound eyes many flies possess small simple eyes, or *ocelli*, which are generally three in number and are set in a triangle, apex forwards, on the top of the head near the occipital margin.

The antennæ (Fig. 1) are one of the principal means of classifying flies. In one great group, of which the mosquito is a good example, the antennæ, like those of most insects, are long and slender, and are composed of numerous segments all of which, except one or two at the base, are alike. In another great group, of which the common house-fly is a

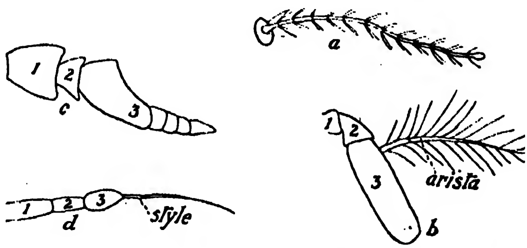

FIG. 1.—Antennæ: *a*, Mosquito; *b*, House-fly; *c*, Gadfly; *d*, Asilid.

good example, each antenna consists of 3 dissimilar segments, the terminal one being much produced ventrally, and bearing far back on its true dorsal surface a feathered bristle, or *arista* (Lat. *arista* = the awn of an ear of corn). Between these two extremes there is a series of gradations; for instance, in the gadfly the antenna consists of 3 dissimilar segments, the third of which is compounded of several firmly united rings; and in certain other flies the antenna is formed of 3 dissimilar segments, the third of which may carry a terminal or subterminal bristle, or a slender *style* which may be compound.

At the lower front of the head is the mouth-cavern, which is usually roofed in by the clypeus. The visible mouth-parts are the "*proboscis*" and the *maxillary palps*, and in some flies these can be withdrawn almost out of sight into the mouth-cavern. There is one family of flies—the *Œstridæ*—in which

the mouth-parts and even the mouth are vestigial. The proboscis is a composite structure, and the exact homologies of its component parts are somewhat problematical. It is generally assumed that the proboscis, as seen without dissection, is the *labium*; it forms a sheath for the other mouth-parts, which lie concealed in a deep groove that runs along its dorsal surface. The parts so ensheathed by the labium are not constant, as may be observed by comparing the proboscis of a female mosquito with that of a blow-fly.

In the female mosquito (Fig. 2) the labium is long and slender, and ends in a pair of small stiffish lobes, the *labella*. In the groove of the labium lie (1) the long pointed upper-lip, or *labrum-epipharynx*; and (2) the slender *hypopharynx*,

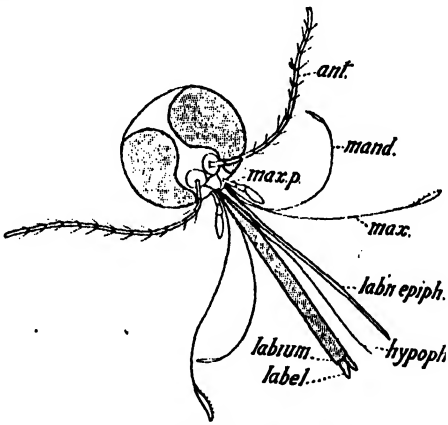

FIG. 2.—Head of female Mosquito.

which is traversed in all its length by the common salivary duct. The labrum-epipharynx is grooved all along its ventral surface, and the groove is converted into a tube by the apposition of the epipharynx: up this tube the blood is drawn when the "mosquito" bites a victim. Besides these two tubes—an efferent salivary tube tunnelled in the hypopharynx, and an afferent suctorial tube formed by the apposition of the hypopharynx to the epipharynx—there exist two pairs of organs which are regarded as homologous with the *mandibles* and *maxillæ* of insects, such as the cockroach (Fig. 112) that feed on solid food. Both mandibles and maxillæ are long, slender, flexible rods slightly broadened

and serrated at the tip, the maxillæ being much more coarsely serrated than the mandibles; they are used with the epipharynx for piercing the integument of the victim.

In the blow-fly (Fig. 3) the labium is stout and fleshy, and ends in a pair of large, oval, expansile labella; its groove is a deep trough, which is closed above by the epipharynx and hypopharynx and so converted into a suctorial tube. Mandibles and maxillæ are not recognisable as independent organs; if they exist at all, which is very doubtful, they are represented by short chitinous vestiges incorporated in the labium.

The maxillary palps vary in form, and are a useful means

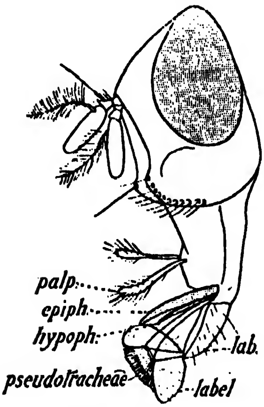

FIG. 3.—Head of Blow-fly.

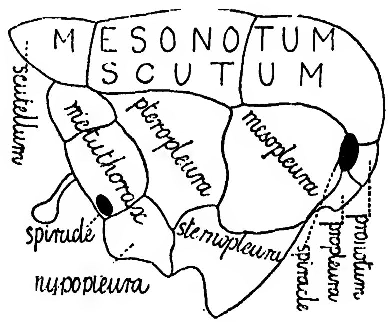

FIG. 4.—Thorax of Tsetse-fly.

of classifying flies. In the flies that have long, slender, many-segmented antennæ the palps also, as a rule, are long, slender, and flexible, and usually consist of 4 or 5 segments. In the flies that have an antenna of 3 segments and a dorsal bristle, such as the house-fly, the palps are unsegmented and stiff. In flies such as the gadfly the palps, which also are stiff, are composed of 2 segments. In some flies (e.g. *Glossina*) the palps form a loose adjustable sheath for the proboscis.

The *thorax* (Fig. 4) is deep, and has much the form of an inverted pyramid. The three thoracic segments are firmly united, though the sutures between them can be distinguished. The prothorax is so much contracted that in a dorsal view

its pronotum is either not seen at all, or shows only as a sort of collar or a pair of shoulder-knots. The metathorax also is small, and its metanotum is more or less overlapped dorsally by the mesonotum. The mesothorax on the other hand is so large that in a dorsal view its mesonotum fills almost the whole field of the thorax: it consists of two parts, namely, a larger anterior part, or *scutum* (Lat. *scutum* = buckler), and a smaller posterior lobe, or *scutellum* (diminutive of *scutum*), which overhangs the metanotum: the scutum is sometimes divided into two nearly equal parts by a *transverse groove.* The sides, or *pleura*, of the thoracic segments are greatly developed; their somewhat complicated structure is explained in Fig. 4. In the pleura of the prothorax and metathorax the large anterior and posterior spiracles are placed. Notice should be taken of the sternopleural and hypopleural plates, as the large bristles borne by them are of systematic importance in dealing with the *Muscoidea.*

The *legs* consist of the usual segments—coxa, trochanter, femur, tibia, and tarsus, the tarsus being composed of five pieces. The coxa may be long or short. The first tarsal segment is sometimes elongate and is often spoken of as the "metatarsus," an ill-chosen term which it is perhaps better to drop: the last tarsal segment carries a pair of claws, and ventral of these there may be a pair of membranous pads or *pulvilli* (Lat. *pulvillus* = a little cushion); between the claws there often exists a small median appendix—the *empodium* (ἐν = on; πόδιον = the foot)—which may be either bristle-like, or broad and membranous like the pulvilli.

The *wings*, as of the majority of insects, are simple folds of integument supported by veins or nervures, and they are membranous, though they may be covered with hairs or scales. Only the anterior (mesothoracic) pair is present, and even they are occasionally absent (wingless flies). Near the root of the wing, posteriorly, there is a notch—the *axillary notch*—which marks off a small lobe—the *posterior lobule.* Internal to the posterior lobule there are often one or two smaller membranous plates (one lying above the other when there are two) known as the *tegula* and *antitegula* (or *squama* and *antisquama*); these probably facilitate the closing and opening of the wings, since they are often very

longitudinal is very short and takes off from the 2nd at a right angle; the 4th and 5th longitudinal veins both bifurcate; there is no posterior cross-vein, and so no discal "cell"; both of the basal "cells" are long; there is no posterior basal cross-vein, and so no enclosed anal "cell."

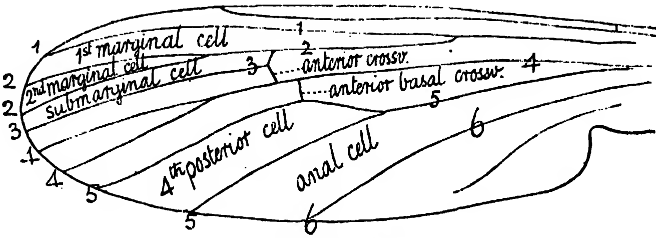

FIG. 7.—Wing of Mosquito.

It should be mentioned that in the wings of some flies faint traces of a longitudinal vein, or even of two may be seen behind the 6th.

The *abdomen* is compact, but the segments are usually distinct. The number of visible segments varies from 4 to 8 or (rarely) 9. When the number of visible segments is small, it is generally the case that several inconspicuous posterior segments are present (and, perhaps, are *introverted*, or telescoped inwards) to form in the female an *ovipositor*, and in the male a part of the inseminating apparatus, or *hypopygium* (ὑπό = beneath; πυγή = rump).

Integument of Diptera.—The chitinous cuticle is often beset with hairs, or bristles, or sometimes with scales. In addition to this general investment, which may be either thick or sparse, there sometimes occur definitely placed bristles of larger size which have received special names according to their situation. Among these the following may be mentioned as their names, perhaps, are not self-explanatory: (*a*) *vibrissæ*—these are two strong bristles sometimes found near the upper angles of the mouth-cavern, one on either side; (*b*) *dorso-central*—these are bristles sometimes inserted in rows in the field of the mesonotum; (*c*) *sternopleural*—these are large bristles sometimes found on the pleural plate that lies immediately above the middle legs; (*d*) *hypopleural*—smaller bristles sometimes inserted in

a tuft, or in a vertical comb, on the pleural plate that lies immediately above the hind legs; (*e*) *discal*—bristles sometimes occurring in pairs in the middle of the abdominal terga.

Alimentary Canal (Fig. 8).—The mouth leads to a muscular pharynx which acts like a suction pump. Connected with the œsophagus there are one or more "crops" or food-reservoirs, the ducts of which may be almost as long as the œsophagus itself. The stomach is large and distensible, its anterior portion, or *proventriculus*, having a thick, glandular epithelium. The intestine is coiled, and ends in a rectal pouch, which has several (usually four) large glandular papillæ on its wall. At the junction of the stomach and intestine the long, coiled Malpighian tubules, which are

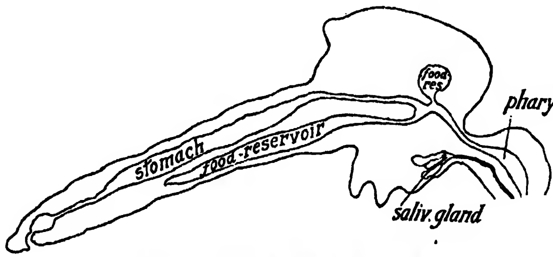

FIG. 8.—Alimentary Canal of Mosquito.

usually four in number, open. The salivary glands are large, and their common duct opens at the tip of the hypopharynx.

Reproduction.—Most flies lay eggs, which are usually deposited, in a manner that simulates conscious foresight, in a medium or in a pabulum suitable to the future larva: the eggs are large, and are often sticky, so that they cohere in masses. Some flies, such as the flesh-flies (*Sarcophaga*), give birth to small living larvæ; and there are others, such as *Glossina* and the *Pupipara*, that retain and nourish the larva in the oviduct, and do not deliver it until it is full-grown and ready to transform into a pupa. In these last only one full-grown larva is born at a time, but other Diptera produce many eggs (or small maggots) at a birth.

The *larva* may be either an *eruciform maggot* (Lat. *eruca* = a grub), or may be fairly well endowed. The typical eruciform larva is a segmented worm-like creature

with a head so small as to be almost invisible, and without appendages except a pair of minute papilliform antennæ and a pair of chitinous mouth-hooks. Some grub-like larvæ may have, in addition, stumpy pseudopods like those of caterpillars, on some of the segments.

Another type of larva is exemplified by that of the mosquito, which has a distinct head, thorax, and abdomen, the head being provided with eyes and well-pronounced antennæ, and also with mandibles, maxillæ, and other organs for discriminate feeding.

Dipterous larvæ are sometimes classified according to the arrangement of their spiracles or breathing-openings. Those that have two pairs of spiracles—one pair at each end of the body—are known as *amphipneustic* (ἀμφί = at both ends, and πνευστικά = things for breathing): those that have only one pair of spiracles placed at the posterior end of the body are called *metapneustic* (μετά = behind, and πνευστικά); while peripneustic larvæ (περί = round about, and πνευστικά) are those with numerous spiracles arranged in segmental pairs along either side of the body.

The larvæ of Diptera show much diversity in mode of life. Some live in water, both fresh and salt, and are thoroughly aquatic animals; many live in decaying organic matter of all kinds; others are parasites of living plants; others are parasites of the larvæ of other kinds of insects; others are intestinal and subcutaneous parasites of vertebrate animals; others are predatory and rapacious, seizing other insects and small animals and eating or sucking them; while there is one, known as the Congo floor-maggot, which is a blood-sucker and has much the habits of a bed-bug.

The *pupa* may be either "coarctate" (Lat. *coarctatus* = confined, *i.e.*, confined in its larval skin), or "obtected" (Lat. *obtectus* = protected, *i.e.*, merely protected by a chitinous secretion).

In the coarctate form the pupating larva shrinks in its skin, so that the resulting pupa lies in a case or *puparium*, formed by the hardened skin of the larva.

In the obtected form the larva as it pupates casts off its skin, and the pupa is enveloped only in its own chitinous pellicle.

The pupa of the house-fly is an example of a coarctate pupa; that of the mosquito is an example of an obtected pupa.

In some flies (e.g. *Simulium*, Fig. 33), the pupa is enclosed in a silky cocoon which is spun by the larva as a preliminary to pupation.

The mature fly, or *imago*, escapes from the pupal shell or the puparium in one of two ways. In the case of the coarctate pupa the anterior end of the puparium is usually pushed off by a distensible bladder-like sac, known as the *ptilinum* (? πτίλον = a plume), which protrudes like a hernia from the "forehead," or front, of the emerging fly (Fig. 9).

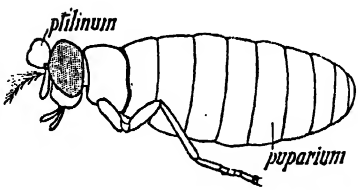

FIG. 9.—Blow-fly emerging from Pupal Case.

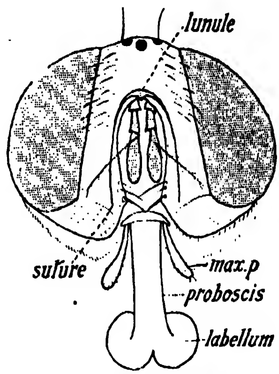

FIG. 10.—Muscid Head.

When the fly has crawled out of the ruptured puparium the ptilinum shrivels, and is ultimately retracted into the head of the fly; but a record of its existence is left in the form of a crescent-shaped scar, known as the *frontal lunule* (Fig. 10), which embraces the roots of the antennæ. Where the distension of the ptilinum has been great, the ends of the frontal lunule are produced far down the face on either side of the antennæ, these extensions of the scar being known as the *frontal suture* (Fig. 10).

In the case of the free or obtected pupa the pupal skin is split either longitudinally down the back, or in a T-shaped fashion, or transversely, and the fly withdraws itself much as a hand is withdrawn from a glove.

Classification of Diptera.

According to the generally accepted scheme of Brauer, Diptera are grouped in two suborders which are defined as follows:—

Suborder 1. *Orthorrapha* (ὄρθος = straight; ῥαφή = seam or suture). Larva with a differentiated head, pupa usually obtected. The imago escapes from the pupal envelope by a straight dorsal slit which is usually longitudinal and sometimes transverse, so that it has no frontal lunule and suture.

Suborder 2. *Cyclorrapha* (κύκλος = a circle; ῥαφή = suture). Larva without a differentiated head, pupa coarctate. The imago escapes from the puparium through a *circular* split at the anterior end, the opening being, typically, made by the extrusion of a ptilinum; a frontal lunule, therefore, is usually present though sometimes it is not very plain. In this suborder the antennæ are usually composed of 3 segments, the third of which is often elongate and carries a bristle, or *arista*, which is generally dorsal, but occasionally terminal. The 3rd longitudinal vein of the wings is not forked, and the number of complete posterior cells does not exceed three. The empodium is never pulvilliform.

1. Suborder ORTHORRAPHA.

The suborder Orthorrapha consists of two series of families as follows:—

Section 1. Orthorrapha *Nematocera* (νῆμα = a thread; κέρας = horn, or antenna). Commonly midge-like flies. The antennæ for the most part are elongate filaments composed of numerous similar, or nearly similar, segments. (The number of segments is often 14 or 16; it may be less than 14, but is never less than 6, or it may be more than 16.) The maxillary palps are, for the most part, elongate and flexible, and commonly consist of 4 or 5 segments, but sometimes of less than 4. The 2nd longitudinal vein is often forked, the 3rd rarely; a discal cell is present only in two families (*Tipulidæ* and *Rhyphidæ*).

Section 2. Orthorrapha *Brachycera* (βράχυς = short; κέρας

=horn, or antenna). Flies which are not, or very seldom, midge-like. The antennæ are of diverse form: usually they consist of 3 dissimilar segments, the 3rd of which is often elongate, is sometimes compounded of a series of indistinctly-separated subsegments, and often carries a style or an arista, which is terminal, or subterminal, or, rarely, dorsal. (In certain species of one family (*Leptidæ*) the antennæ consist of a large number of segments, and in that respect resemble the antennæ of Nematocera.) The maxillary palps are usually composed of 1 or 2 segments and are not flexible. The venation of the wings is often complex; the 2nd longitudinal vein is not forked, but the 3rd often is.

2. Suborder CYCLORRAPHA.

The suborder Cyclorrapha is divided into two sections, as follows:—

Section 1. Cyclorrapha *Aschiza* (ἀ privative, and σχίζα = a cleft), in which the frontal lunule is more or less indefinite, and a frontal suture is not present at all.

Section 2. Cyclorrapha *Schizophora* (σχίζα = a cleft, and φορέω = I wear), in which both the frontal suture and frontal lunule are always well defined. None of the veins of the wings are forked.

The Cyclorrapha Schizophora again are divided into two subsections, as follows:—

Subsection 1. *Muscoidea*, of which the common house-fly is a typical example.

Subsection 2. *Pupipara*, or "Tick-flies," blood-sucking parasites which live among the hairs of mammals or among the feathers of birds.

CHAPTER III

Order Diptera (*continued*): The Nematocera. Blood-sucking Nematocera: Culicidæ

WITH few exceptions the *Nematocera* are midge-like flies, with filamentous antennæ and slender maxillary palps, both antennæ and slender maxillary palps commonly being of considerable length; the 3rd longitudinal vein is rarely forked.

Williston, whose standard work on North American Diptera is followed here, accepts twelve families of Nematocera. The majority of the species (the *Bibionidæ*, *Simuliidæ*, and *Orphnephilidæ* furnish the most notable exceptions) are more or less midge-like in form, having the body and legs long and slender, and usually having long, many-segmented antennæ which often carry whorls of hairs.

Synopsis of the Families of Nematocera.

1.	Body and wings thickly covered with hair like a moth	= *Psychodidæ*.
	Flies not resembling moths	= 2.
2.	Wings with a network of fine vein-like creases besides the ordinary veins	= *Blepharoceridæ*.
	Wings without any additional network of vein-like creases	= 3.
3.	Scutum usually with a V-shaped transverse suture; wings usually with a discal cell	= *Tipulidæ*.
	Scutum without a transverse suture	= 4.
4.	Wings with a discal cell	= *Rhyphidæ*.
	Wings without a discal cell	= 5.
5.	Antennæ abnormal, apparently consisting of 2 segments and a terminal arista	= *Orphnephilidæ*.
	Antennæ normally nematocerous	= 6.
6.	Posterior edge of wing fringed with *scales*	= *Culicidæ*.
	Posterior edge of wing *not* fringed with scales	= 7.

7. Minute fragile midges; wings commonly with only three longitudinal veins = *Cecidomyidæ*.
Not abnormally delicate and fragile; wings usually with numerous veins = 8.

8. Ocelli present = 9.
Ocelli absent = 10.

9. Coxæ elongate; antennæ usually elongate; *all* the tibiæ end in spurs = *Mycetophilidæ*.
Coxæ short; antennæ usually shorter than the thorax = *Bibionidæ*.

10. The costal vein extends all round the wing = *Dixidæ*.
The costal vein stops at or near the tip of the wing = 11.

11. Gnat-like flies with long slender legs; antennæ filiform, often with whorls of hairs = *Chironomidæ*.
Thickset flies with stout legs; antennæ stout and stiff, hardly longer than the head, and never having whorls of hairs; wings remarkably broad = *Simuliidæ*.

Of the twelve families that constitute the section *Nematocera*, only four are known to include species that suck blood and attack man. There is good reason to believe that with most of these species the females alone have this habit; in many cases, indeed, it is certain that the male can not depend upon blood, as its mouth-parts are not capable of piercing epidermis.

The four families which are thus of interest to the medical officer are:—

(1) *Culicidæ* or Mosquitoes (p. 48). In the great majority of the species of this large and cosmopolitan family the females have mouth-parts made for piercing (Fig. 2), and therefore are, or may be, blood-drinkers.

(2) *Psychodidæ* or Moth-like Midges (p. 115). In this family the species of only one genus, *Phlebotomus* have piercing mouth-parts and are notorious blood-suckers. The species at present known are about a score in number, and have been recorded in all the great zoological regions except the Australian. In some species, if not in all, the mouth-parts of the male are quite as formidable as those of the female.

(3) *Chironomidæ*, or Midges (p. 120). Only a few species of this enormous family are specialised for a diet of blood, and these are all of minute size and belong to the subfamily *Ceratopogoninæ*, which is represented in all parts of the world.

(4) *Simuliidæ* (p. 123). All the species (numbering more than 100) of this family are extremely bloodthirsty, and the females have mouth-parts of a most trenchant type (Fig. 30). The family is represented in all parts of the world.

These four families will be reviewed first.

(a) *Blood-sucking Nematocera.*

Family CULICIDÆ.

The Culicidæ can be distinguished from all other midge-like flies by the venation (Fig. 7), and by the close fringe of scales on the posterior border of the wings; usually also they have a projecting proboscis of extraordinary length.

The head is small and subspherical, and there is a distinct neck; the crown and the cheeks are covered with scales which show specific differences. The eyes are reniform, and there are no ocelli. The antennæ, which are long and slender, are composed of 14, sometimes 15, segments, the first being globose and broadly sessile on the head, while the others are cylindrical, and carry—most of them—whorls of hairs, which in the female are wispy, but in the male are, as a rule, so thick-set as to give the antenna the look of a small bottle-brush. The clypeus is prominent. The labium (proboscis) in the majority of Culicidæ is long and slender, is covered with scales, and ends in a pair of small stiffish labella; it is not employed for piercing or sucking, but is arched downwards during these operations, the labella then being used as guides for the piercing organs. The maxillary palps, which also are covered with scales, show specific and sexual differences, being sometimes longer than the proboscis, and sometimes very short. The parts ensheathed in the proboscis also differ according to species and sex. In one small subfamily (*Corethrinæ*) they are short, and are not formed for piercing; but in the females of all other Culicidæ they are long sharp piercing organs, and consist of the following parts (Fig. 2):—(1) a stoutish, pointed epipharynx, which is grooved ventrally; (2) a slender hypopharynx, which—itself an efferent tube for the saliva—is applied to the epipharynx so as to convert the groove of the latter into an afferent suctorial tube; (3) a pair of slender mandibles

expanded and very finely serrated at tip; (4) a similar pair of maxillæ which are more coarsely serrated at tip. In the males of Culicidæ (Fig. 11) mandibles and maxillæ are wanting, and often also the hypopharynx is hard to trace as an independent structure, the proboscis appearing to consist solely of epipharynx and labium, which resemble the same parts of the female; the males do not suck blood, but live on juices.

The thorax is covered with scales or hairs, the form and distribution of these being subject to some diversity. In a dorsal view the predominant segment is the mesothorax, or, rather, its dorsal elements, the scutum and scutellum. The

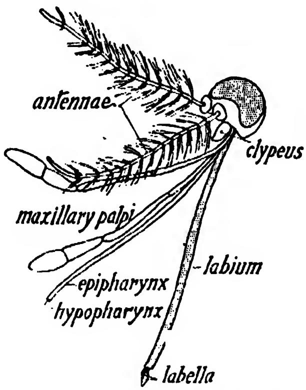

FIG. 11.—Head of male *Anopheles*.

pronotum, or dorsal element of the prothorax, shows only as a narrow collar or a pair of shoulder-lobes. The metanotum is overlapped by the scutellum, and as a rule is quite bare. The scutellum itself is narrow; its free edge is commonly trilobed, but sometimes is simply arched. There is no "transverse suture" to the scutum.

The abdomen, which is long and narrow, consists of 9 segments, the last one of which is bilobed. In the female the two terminal lobes are simple, but in the male they have a complicated structure, and carry a pair of slender, chitinous, clasping-hooks. The surface of the abdomen is either scaly or hairy.

The wings (Fig. 7) are long and narrow, and are completely encompassed by the costal vein; their front edge (the

wing is always supposed to be extended at right angles with the body) is beset with stiff bristle-like scales, and the hind edge is ornamented by a characteristic fringe which consists of scales of two forms, namely, short, broadish, closely appressed *border-scales*, and long, narrow, outstanding *fringe-scales* of two lengths. The characteristic features of the venation are (1) that the subcostal vein is long; (2) that the 2nd, 4th, and 5th longitudinal veins all bifurcate; (3) that the 3rd longitudinal vein is short, and commonly takes off from the second at such an angle that its origin is sometimes spoken of as a "supernumerary cross-vein"; (4) that there is no true posterior cross-vein (though the anterior basal cross-vein is sometimes wrongly called by that name), and no posterior basal cross-vein; and (5) that all the veins are clad with scales, except in the small subfamily *Corethrinæ*, where hairs take the place of scales. These scales, as a rule, are of two kinds, namely, short, broadish, "median" scales that cling to the vein, and longer and narrower "lateral" scales that stand out on either side of it. Another wing-feature that must be noticed is that besides the ordinary longitudinal veins there are generally two longitudinal creases or false veins: one of these looks like a continuation of the 3rd longitudinal vein; the other looks like a 7th longitudinal vein. This last in one or two species only, bears a few scales.

The halteres are plainly visible, there being no squames to conceal them.

The legs, which are clad with scales, are long and slender, the 1st tarsal segment (which is sometimes, by a sort of metaphorical inversion, spoken of as the "metatarsus," as if the metatarsus of the vertebrate skeleton were the proximal element of the sole of the foot instead of being the distal element) contributing a very considerable part of their length. The 5th tarsal segment carries a pair of claws, which in the male may be serrated.

The main features of the alimentary system are shown in Fig. 8.

The male differs from the female most conspicuously in the form of the antennæ.

The eggs of Culicidæ are laid on the surface of water either in a sheet of jelly something like diminutive frog-

spawn (*Corethra*), or in groups or "rafts" (e.g. *Culex*), or singly (e.g. *Anopheles*). The individual egg is oval, with one end blunter than the other, and has a pigmented chitinous shell. A very fine external membrane either adheres closely to the shell, or invests it more or less loosely (as in *Anopheles*) so as to leave a space or "float" on either side of the egg. The eggs of some species may hatch within twenty-four

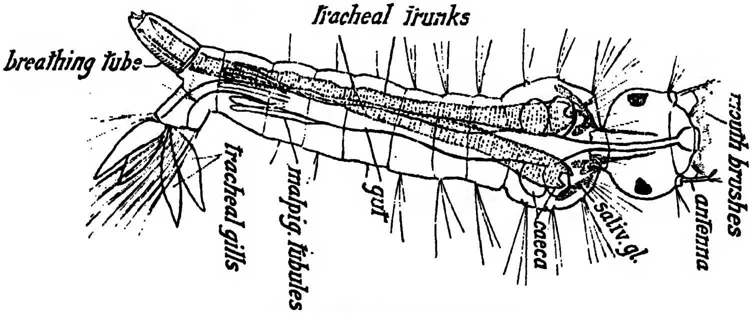

FIG. 12.—Larva of *Stegomyia fasciata*.

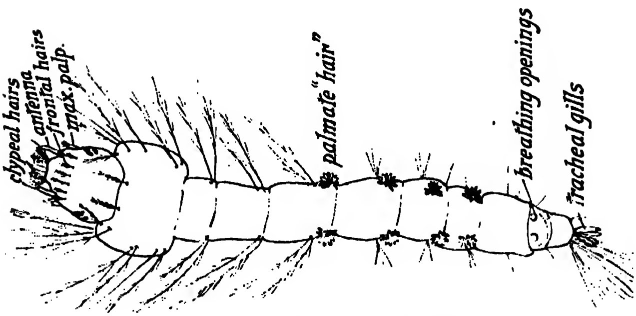

FIG. 13.—Larva of an *Anopheles*.

hours *in the hot season* in the tropics, but cold retards their development.

The larvæ (Figs. 12, 13) show considerable differences of structure and habit, and the following general description, which, however, does not apply to *Corethra* and *Mochlonyx*, is meant to clear the way for subsequent consideration of the specific forms. They are specially formed for an aquatic life and are unable to live out of water, and they may be found in collections of water of any kind, small or large,

natural or artificial, temporary or permanent, or even in pools of sea-water; but they are not found in any parts of streams or rivers where the current is rapid. They are extremely active, and though their food usually consists of algæ and such vegetable matter, there are some species that are carnivorous and predatory.

The three regions of the body in the Culicid larva are all well defined.

The head (Figs. 14, 15) is a rounded chitinous capsule with well-developed appendages, and all its parts show specific differences. The eyes in the young larva are rather irregular masses of pigment, but in older larvæ they become indistinctly faceted. The antennæ are, for a larva, long. The clypeus

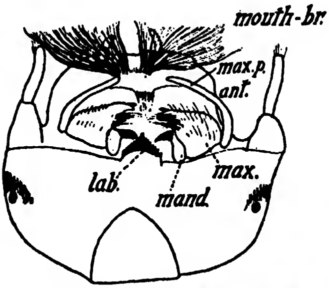

FIG. 14.—Head of a non-rapacious Larva.

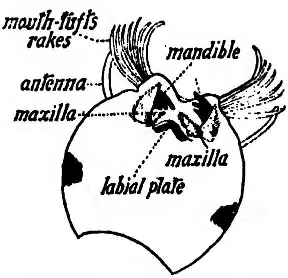

FIG. 15.—Head of a rapacious Larva.

is prominent, and on either side of it are attached large tufts of hairs; these, which are known as "mouth-brushes," have a rotatory motion and are used for sweeping food into the mouth. In predatory larvæ the brushes may be replaced by combs, or rakes, of stout chitinous prehensile bristles or hooks (Fig. 15). The mandibles are strongly chitinised, sharply serrated, and usually dark coloured. The maxillæ are bilobed plates fringed with hairs, the outer lobe sometimes being elongate. The labium is represented by a dark coloured, triangular, chitinous plate, the edge of which is more or less serrated. On the front of the head, between the antennæ, hairs of various forms, but of definite arrangement, are often found.

The thorax is a broad mass which shows its composition of 3 segments only in the serial arrangement of its hairs;

these may be in tufts, or may be single branched or feathered hairs; sometimes the hairs are replaced by bristles, or occasionally by spines.

The abdomen, which is elongate and is the softest part of the body, consists of 9 distinct segments. Sometimes (particularly in the case of those jungle larvæ that habitually live in the drops of fluid that collect in holes in trees, in leaves, in pitcher-plants and other such places, where they are peculiarly liable to the attentions of insectivorous birds) the whole abdomen is beset with tufts of stiff hairs like a "woolly-bear" caterpillar; but more often the hairs are restricted to or are only conspicuous at the sides of the anterior segments and the free edge of the last segment. On the dorsum of the 8th segment the breathing-organs open, either by two independent orifices in a hollow at the base of a papilla (as in the *Anopheles* group), or at the end of a chitinous breathing-tube of varying length. The breathing-tube, when present, has a valvular opening, and on its under-surface are one or two rows of spines, the number and form of which are specific. On the sides of the 8th segment also there are generally some scattered scales. The 9th segment is the smallest, the intestine opens at its free end, where there are also found bunches or wisps of hair of extraordinary length, and four tapering tracheal gills of varying size.

The principal features of the internal structure are shown in Fig. 12. The broad digestive tube passes straight through the body, with glandular dilatations in the thorax, and receives the five Malpighian vessels in the 6th abdominal segment; the two main tracheal trunks run dorsal of and parallel with it, and end abruptly in the thorax at the point where the air-openings of the pupa will subsequently appear.

The larva progresses by energetic wriggling movements. In repose some larvæ hang head downwards, with the tip of the breathing-tube at the surface of the water; but the larvæ of the *Anopheles* group, and some others also, lie horizontally at the surface.

The larva feeds continuously and moults occasionally, and in the most favourable circumstances of food and warmth becomes full grown in little more than a week; but cold

retards growth, and in northern latitudes some larvæ both of *Anopheles* and *Culex* remain unchanged throughout the winter.

The pupa (Fig. 16) is of the naked or "obtected" kind; it also is formed for an aquatic life, and though, of course, it does not feed, it is active. In shape it is something like a tiny lobster deprived of appendages and carrying its tail bent. The head and thorax form one large mass, and through the chitinous skin the eyes and wings can be seen, as well as the folded appendages; from the back of the mass a pair of ear-like breathing-trumpets projects; these have open ends, and are lined by short interlacing hairs which prevent water from entering. The curved abdomen consists of 9 segments, and ends in a pair of large blade-like fins; on the dorsum

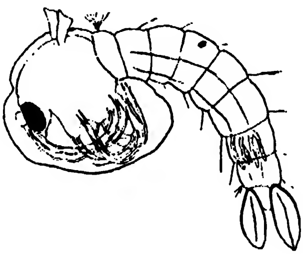

FIG. 16.—Pupa of a *Culex*.

of the 1st segment there is a pair of large fan-like tufts of hairs, the use of which is to catch the surface film and to buoy the pupa in such a position that the air-trumpets may act. The duration of the pupal stage is, as a rule, short—about two days in hot weather, but a week or more in colder weather.

When the adult is about to emerge, the pupa straightens out and the skin of the cephalothorax bursts along the back; the head of the adult then appears, followed gradually by the body and appendages. After delivery the insect rests for a few moments on its old pupal envelope until its wings are hardened and fit for flight.

Any account of the three principal diseases—filariasis, malaria, and yellow fever—which the great discoveries of Manson, Ross, Grassi, and the distinguished members of the American Yellow Fever Commission have shown to be

due to the agency of mosquitoes, would be out of place here, where we are concerned only with the insects themselves and with the means that are to be adopted to keep them in check.

The mosquito, like many other animals that breed in a defined environment is most vulnerable in its larval stages. To attack the larva is universally admitted to be the first object of the sanitarian.

There may be circumstances in which it is impossible to proceed against the larvæ, as in a country of illimitable swamp. In such a case man must defend himself against the attacks of the adult mosquitoes, and must drug himself against the parasites that they harbour.

(a) *Warfare against Mosquito-larvae.*

Every medical officer should make a point of identifying, both in their adult and larval stages, all the common mosquitoes of his district. The most methodical procedure is to collect and rear the larvæ. Rearing can be done in wide-mouthed bottles capped with gauze. A separate bottle should be used for each kind of larva, and each bottle should be numbered. A piece of clean waterweed should be kept immersed in each bottle to keep the water sweet, and the daily loss by evaporation must be made good. In stocking the bottles, and always in adding water, particular care must be taken that no (possibly predaceous) aquatic animals of other kinds get in. Samples of full-grown larvæ of each kind must be preserved in spirit, and labelled to correspond with the bottles from which they are taken. When the adults hatch out from their pupal skins they should not be killed at once, lest they shrivel, but they should be given a chance of feeding on a piece of fruit.

Some mosquitoes, such as *Stegomyia fasciata* and *Culex fatigans*, will lay their eggs in anything that is meant to hold, or is *not* meant to hold, water, from the harmless necessary water-butt to the dregs of an ill-kept drain, or the few drops of rain that collect in an old tin or a broken bottle. Even some of the malaria-carriers will breed in casual pools of rain-water, and in the water-courses used in irrigating gardens. Other malaria-carriers breed in ponds, tanks, marshes, and the sedgy reaches of sluggish rivers and backwaters. Many larvæ can live quite happily in brackish and salt water; even the common *Culex pipiens*-larva has been taken in pools to which the sea has access.

Many species—chiefly jungle-mosquitoes of no account to the medical officer—deposit their eggs in the water that collects in holes in stumps and forks of trees, in the hollows of bamboos, in the curious leaves of pitcher-plants, and sundry such places; but even *Stegomyia fasciata* will breed in places of that kind.

A strict enforcement of ordinary sanitary regulations will do much to extinguish, in any given locality, the species that depend upon house water, drains, and puddles. Wells, cisterns, and water-butts must be kept covered, holes must be filled in, surface drains must be kept clean, jungle must be cleared away, and broken crocks and old tins and everything of that sort must be stamped flat and buried. Where cesspools exist they must be treated with petroleum.

Beyond the immediate precincts of the house all unnecessary ponds must be filled in, and surface drainage must be looked to. Village tanks that are required for use can be treated at regular intervals with petroleum, a thin surface-film of which is said to clog and choke the breathing-holes of the larvæ.

Drinking-tanks, which would be spoilt by petroleum, can be treated from time to time with sulphate of copper: it has been found in several places that this salt in a solution too diluted to affect the most sensitive human stomach makes life difficult for mosquito-larvæ by destroying the minute algæ that form the staple of their food.

In brief, it is admitted by all reasonable people that the chief thing is to make life impossible for mosquito-larvæ by clearing, draining, and levelling, by strict attention to sanitary minutiæ, and by instituting a domestic water-supply that is independent of wells and ponds.

As to natural enemies of mosquito-larvæ: no zoologist is disposed to question the established "laws" of Nature, or to dispute the obvious truth that in nature mosquitoes, like all other forms of life, must be kept within bounds by competitors and foes. But the existence of civilised man is a standing protest against the works of Nature, and it seems doubtful whether in his operations against mosquito-larvæ, any more than in his struggles against the many other ills that flesh is heir to, the medical officer will get much comfort

by relying on Nature's unassisted processes. However, "Natural Enemies" is now a potent formula, and it behoves the medical officer to consider it, if only in self-defence.

It is generally known that many small fish eat mosquito-larvæ, and among the most useful in this kind are the small fishes of the family *Cyprinodontidæ*, different species of which are found all round the globe in low latitudes; they thrive in any kind of water, and most of them can live happily wherever a *Culex-* or *Stegomyia*-larva can. The usefulness of fish is most apparent in small islands, where the conditions of life are comparatively simple. Thus in Barbados small Cyprinodonts, known locally as "Millions," are said to be an effective check on mosquitoes; and many years ago, when I was in the Laccadive Islands, I noticed that in Minnikoy, where there were no fishes in the wells and tanks, mosquitoes were a terrible pest, whereas in Aucutta, where the tanks and wells contained multitudes of small barbels and perches, no mosquitoes were seen (*Naturalist in Indian Seas*, 1902, p. 201).

It is well known that the aquatic larvæ of the "Demoiselle" dragon-flies of the *Agrion* group (p. 259) are very destructive to mosquito-larvæ. These dragon-flies are common in the tropics, and their larvæ are abundant in stagnant water.

Among other probable or possible enemies the following common and widely distributed aquatic insects may be mentioned: beetles and their larvæ of the families *Dytiscidæ* (p. 234), *Gyrinidæ* (p. 235), and *Hydrophilidæ* (p. 235); larvæ of many *Ephemerida* (p. 257); larvæ of *Plecoptera* (p. 256); several families of aquatic bugs (p. 210); larvæ of the Chironomid fly, *Tanypus* (p. 122). The aquatic larvæ of the *Sialidæ* (p. 260) are also carnivorous, but they are not found in the tropics. Some aquatic larvæ of Caddis-flies (p. 262) are predaceous, though the Caddis-worms of this habit usually live in quick-flowing water.

Of Culicid larvæ themselves there are many species that are predatory and may devour their fellows of other species; *Corethra* (p. 60), *Mochlonyx* (p. 61), and *Megarhinus* (p. 113) are good examples. These carnivorous larvæ can be recognised by their powerful mandibles, and by having either the antennæ or the mouth-brushes specially modified for prehension.

Dr Atkinson, of Hongkong, reports that the adults of a water-haunting Dolichopodid fly (p. 141), and of an Anthomyid fly of the wide-ranging genus *Lispa* (p. 180) devour mosquito-larvæ. And Dr Annandale, of the Indian Museum, mentions the common fresh-water polyp *Hydra* as a chance foe. Another mortal enemy is a fresh-water Amphipod Crustacean (p. 322) of the genus *Gammarus* (Fig. 136).

Floating plants of the duckweed order (*Lemnaceæ*) are supposed, when they form a very thick growth, to crowd out mosquito-larvæ and prevent them coming to the surface to breathe. Possibly some zealous reformer may some day suggest that the *Utriculariæ* should be cultivated for the purpose of catching mosquito-larvæ.

(b) *Defence against Adult Mosquitoes.*—It is generally agreed that in swampy tracts, where it is impossible to make much impression on larvæ, the adults must be attacked.

Ross, arguing for the prevention of malaria, very properly insists that in all circumstances, even when active measures are taken against larvæ, the adults (and the prophylactic use of quinine) must not be forgotten.

Wind and sun are very bad for mosquitoes, so that everything that is likely to give them shelter from either—creepers, undergrowth, ruins, tumble-down outhouses, etc.—should be cleared away from the immediate vicinity of dwellings.

Dark corners, cellars, sheds, etc., are very good for mosquitoes. All such hiding-places should be looked to, and if necessary, fumigated with sulphur, or sprayed with dilute solution of formalin, or strong solution of crude carbolic acid, or crude petroleum.

Mosquito-proof houses and even mosquito-nets are supposed to be a luxury for the white man, but in the island of Minnikoy, where the population scrapes a precarious living from the coco-nut, everybody—when I was there in 1891—used mosquito-nets.

Mosquitoes can certainly be kept off by petroleum; but a lotion or emulsion of some aromatic oil (clove, anise, peppermint, lavender, bergamot, turpentine, eucalyptus—or a tasteful combination of them) in strong spirit-and-water with a little quassia or quinine is much pleasanter for personal use.

Classification of the Culicidæ.

The elders among dipterists have been content to recognise two subfamilies, namely, (1) *Corethrinæ*, in which the proboscis is short and soft, and the mouth-parts are not formed for piercing, and the veins of the wings are clothed with hairs; and (2) *Culicinæ*, in which the proboscis is stiff and of great length (and the mouth-parts, in the female at least, are formed for piercing), and the veins of the wings are clothed with scales.

Some recent writers, however, ignoring all the common features that distinguish the two subfamilies, in equal measure, from other Nematocerous Diptera, and exaggerating the importance of the functionally different mouth-parts, have cut the *Corethrinæ* adrift, and have given the exclusive possession of the common family title to the *Culicinæ*. Such a proceeding seems to me to defeat the humane objects of a zoological classification, which are to knit together the morphological bonds that should unite diversely modified relatives.

Even when the most is made of the differences between the respective larvæ of *Corethra* and *Culex*, there still remains to be weighed the fact that the larva of *Mochlonyx* (Fig. 18) is, as Miall says, "structurally as exactly intermediate . . . as can well be imagined."

Subfamily I.—CORETHRINÆ.

Williston gives the following synopsis of genera:—

1. Hind "metatarsi" shorter than the following segment — *Mochlonyx*.
   Hind "metatarsi" longer than the following segment — 2.
2. Small species, claws simple — 3.
   Large species (10 mm.), claws bifid — *Pelorempis*.
3. Antennæ verticillate — *Corethra*.
   Antennæ of male thickly clothed with long hairs; of the female with a basal and irregular median circlet of hairs on each joint — *Corethrella*.

The species of *Corethra* are widely distributed. As in *Mochlonyx*, the veins of the wings are clad with hairs, not scales.

The larva of *Corethra* (Fig. 17) is of interest, as, living in the same kind of water as the larvæ of other Culicidæ, it is predatory. It is of such extreme transparency that it is known as the "phantom larva," and in repose it rests horizontally near the surface. The head is produced anteriorly into a kind of snout, at the end of which are the antennæ; these are bent towards the mouth and, ending in a tuft of long bristles, are prehensile. The mouth is remarkable for the talon-like mandibles. The long tapering abdomen ends in four tracheal-gills, and on the ventral surface of its terminal (9th) segment there is a sort of vertical fin, which consists of a row of many long, finely feathered bristles. There is no breathing-tube nor any breathing-opening, the tracheal system being completely closed. Connected with the tracheal

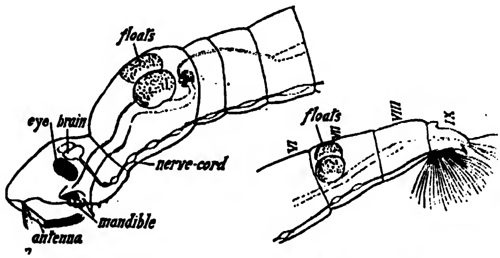

FIG. 17.—Anterior and posterior ends of Larva of *Corethra*.

system there are, on the dorsal surface of the body two pairs of oval, pigmented dilatations or floats; the front pair, which are the larger, are situated side by side, near the middle of the thorax, and probably are homologous with the breathing-trumpets of Culicid pupæ; the smaller, posterior pair are placed on the 7th abdominal segment. The pupa is remarkable for the great size of the tail-fins at the posterior end of the abdomen, and for the pointed shape and extremely narrow opening of the breathing-trumpets of the thorax.

The larva of *Mochlonyx* (Fig. 18) also is predatory; it and its pupa are considered by Miall to be "structurally as exactly intermediate between *Corethra* and *Culex* as can well be imagined"—an opinion which cannot reasonably be disputed, though to the naked eye the larva looks exactly like *Culex*. The larval *Mochlonyx* which, for convenience, is represented in Fig. 18 in an unnatural position, the head being viewed from

above, and the body more from the side, resembles a *Culex* larva (1) in being pigmented; (2) in having on the dorsal surface of the 8th abdominal segment a long breathing-tube through which the tracheæ pass; and (3) in the general shape of the head. The head, however, is characterised by the closer setting of the antennæ, and by the presence on the clypeus of a projecting pencil of long stiff bristles instead of a pair of mouth-brushes. In other respects the larva agrees

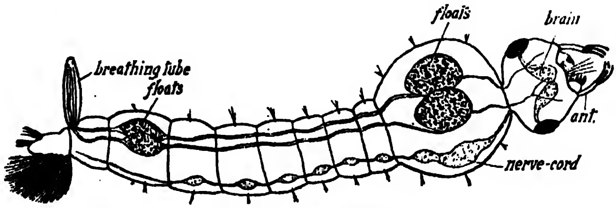

FIG. 18.—Larva of *Mochlonyx*.

with *Corethra*, having (1) the paired, pigmented tracheal floats in the thorax and the 7th abdominal segment; (2) the vertical ventral caudal fin, formed by a series of articulated hairs, on the 9th abdominal segment; and (3) the prehensile antennæ. The antenna, however, is even more efficient of its kind, as it ends in three or four long, stiff grapnels of great strength. The caudal fin also differs from that of *Corethra*, as the individual bristles are branched.

Subfamily II.—CULICINÆ.

Theobald, making the Culicines a separate family, has divided them into ten groups, which he regards as subfamilies. Some of these groups are well defined, others are not; while some of them, which severally include one or two species, are based upon an overrating of characters which, though in a way striking, are, from a broad zoological standpoint, trivial.

For our purposes the grouping of these annoying insects in four sections is recommended as follows:—

A. { Proboscis bent like a pot-hook; very large mosquitoes = *Megalorrhini*.
Proboscis not bent like a pot-hook = 2.

2. Free edge of scutellum simply convex: palpi about as long as the proboscis in both sexes = *Epialurgi.*
Free edge of scutellum trilobed = 3.

3. Metanotum bare = *Culicales.*
Metanotum with a few bristles, or scales, or both = *Metanototricha.*

Theobald has done great service by pointing out the value, for purposes of classification, of the form and arrangement of the scales. The following (Fig. 19) are the principal kinds of scales—not including bristles, hairs, and "hair-like scales"—recognised by this authority:—

On the *head:* curved scales (Fig. *e, f, h*) which will here be called "sickles"; forked scales (Fig. *a, b, c, d*), which will

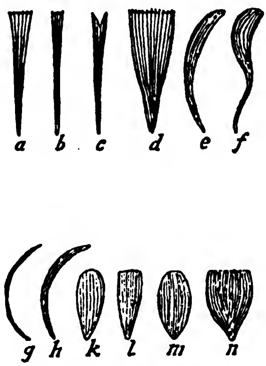

FIG. 19.—Scales of *Culicidæ.*

here be called "darts"; and flat scales (Fig. *k, l, m, n*), which will here be called "squames." All three kinds vary a good deal in detail: all three may coexist (as in *Culex*); or squames alone (as in *Megarhinus*), or darts alone (as in certain species of *Anopheles*) may be present; or there may be a combination of squames and darts (as in certain species of *Stegomyia*).

On the *thorax*, hair-like scales, "sickles" of different forms, and "squames," which may be spatulate, or broadly elliptical, or narrowly elliptical: both hair-like scales and squames may be present (as in *Stegomyia*), or hair-like scales and sickles (as in *Culex*), or elliptical squames alone (as in *Megarhinus*), or (as in some species of *Anopheles*) there may be nothing but hairs.

On the *abdomen*, hair-like scales, broad squames, and long narrow squames. In the majority of the subfamily the abdomen is closely invested with broad imbricating squames; in many species of *Anopheles* there are scattered squames of the long narrow kind; and in some *Anopheles* there are no true scales at all.

On the *wings* the scales have a wide range of specific form, from long narrow scales hardly different, except in stiffness and regularity, from hairs, to broad squames and disks of diverse shape.

The names of the genera of *Culicidæ* are, with a few notable exceptions, so devoid of significance, and they are so often constructed in defiance of the rules of composition, that it is better not to inquire into their derivation.

CHAPTER IV

Culicidæ (*continued*): The Anopheles Mosquitoes

THE Anopheles mosquitoes can be distinguished by the simple curve of the free edge of the scutellum and the straight proboscis; in the female the maxillary palps are equal to the proboscis in length.

We shall treat them here as forming a section of the *Culicinæ*, as follows:—

Subfamily CULICINÆ.

Section I.—*Epialurgi* (= *Anophelinæ* of Theobald); (Gr. ἠπίαλος = ague fever; ἔργον = work).

This section includes the single genus *Anopheles*, with probably about 100 known species distributed in all the great zoogeographical regions, but most abundant in the tropics.

Theobald, using characters exhibited by the scales, has segregated the species of *Anopheles* in more than twenty "genera"; but as this course seems to me to override natural affinities I have not followed it in all its ramifications. It must be admitted, however, that the form and the arrangement of the scales, *when considered along with other characters*, do give help in splitting the genus into groups; but as all these groups can be linked together by annectant forms, it seems to me to be much more natural (as well as more suited to the convenience of the medical officer) to regard them as a series of intergraduating subgenera.

The subgenera here recognised are *Anopheles* (sensu restricto), *Myzorhynchus*, *Arribalzagia*, *Christya*, *Myzomyia*, *Nyssorhynchus*, and *Chagasia*. Under *Nyssorhynchus*, again, three series may for convenience be admitted, namely, *Nyssorhynchus* (restricted), *Neocellia*, and *Cellia;* and under *Myzomyia* two series are suggested, namely, *Myzomyia* (restricted) and *Pyretophorus*.

The Anopheline mosquitoes are of the utmost interest to the medical officer because, so far as is known at present, they include the only species that nurse the malaria parasite. Though there is good reason to believe that in every malarial region there are particular species that are specially concerned in disseminating the parasite, it would be going far beyond ascertained fact to assert at present that there is any species which is everywhere and at all times, impotent to carry infection. What has been conclusively established so far, in places where Anophelines have been studied to this end is (1) that the parasite in one or other of its forms is found, naturally, in some species and not in others; (2) that even in the former species it is not found at every season of the year, although the index of infection in the human population may be constant; and (3) that there are certain species which can not be experimentally infected with the parasite in the laboratory. Every district medical officer, therefore, should endeavour to determine by actual examination of the stomach for zygotes, and of the salivary glands for sporozoites, what local species are naturally infective. The examination should, if possible, be continued through the round of the seasons, and need not be restricted to Anopheline mosquitoes if the medical officer have the proper "cross-bench" mind.

The removal of the stomach is an easy matter. The mosquito, deprived of unnecessary appendages, should be laid upon a slide, in a drop of tepid saline solution. It is held steady by the front end of its thorax with a needle, while with another needle the dorsal and lateral integument between the last two abdominal segments is scratched through. By a steady pull on the loosened last abdominal segment the greater part of the alimentary canal can be drawn out.

To remove the salivary glands the mosquito, prepared as before, is held steady by a needle thrust through the muscles in its back, and its head is drawn well forward so as to make the most of its neck. With another needle the dorsal integument of the neck is scraped through, close to the thorax. By a steady pull in a curve forwards and slightly backwards the salivary glands will come away with

the head; but if the head be dragged straight forward the salivary glands will stop in the thorax.

Among the common species recorded by different observers, hitherto, as natural carriers of malaria-infection, are the following :—

In *Europe* :—

Anopheles maculipennis, Meigen.
 „ bifurcatus, L.
 „ (" Pyretophorus ") superpictus, Grassi.
 „ (Myzorhynchus) pseudopictus, Grassi.

In *Southern Asia* :—

Anopheles (Myzomyia) listonii, Liston.
 „ „ culicifacies, Giles.
 „ (Myzorhynchus) barbirostris, van der Wulp.
 „ „ sinensis, Wiedemann.
 „ (Nyssorhynchus) fuliginosus, Giles.
 „ „ theobaldii, Giles.
 „ (" Neocellia ") stephensii, Liston.
 „ „ willmorii, James.

In *Tropical Africa* :—

Anopheles (Myzomyia) funestus, Giles.
 „ (" Pyretophorus ") costalis, Loew.
 „ (Myzorhynchus) mauritianus, Grandpré.
 „ „ paludis, Theobald.

In *Australia* :—

Anopheles (Nyssorhynchus) annulipes, Walker.

In *North America* :—

Anopheles maculipennis, Meigen.
 „ bifurcatus, L.

In *Tropical America* :—

Anopheles (Myzomyia) lutzii, Theobald.
 „ (" Cellia ") argyrotarsis, Rob. Desvoidy and its varieties.

The following species are known to carry the larva of *Filaria bancrofti* :—

Anopheles maculipennis, Mg.
 „ (Myzomyia) rossii, Giles.
 „ (Myzorhynchus) nigerrimus, Giles.
 „ („) minutus, Theob.
 „ (Myzomyia) funestus, Giles.
 „ (" Pyretophorus ") costalis, Loew.
 „ (" Cellia ") argyrotarsis, Rob. Desv.

ANOPHELES, Meigen (*sensu latiore*); (Gr. ἀνωφελής = unprofitable, harmful).

Head somewhat pyramidal, usually with great abundance of upright forked scales, never covered with imbricating flat scales or with narrow curved scales, though scales of these and other kinds may at times be present. Maxillary palps about the same length as the proboscis in both sexes, clubbed in the male.

Scutum either with hairs, which are often sparse, or with scales, which seldom form a really thick coat. Scutellum with the free edge simply convex, not three-lobed. Metanotum bare.

Abdomen either with sparse hairs alone, or with scales and hairs in varying proportion, the scales being sometimes limited or localised, occasionally fairly abundant, but hardly ever forming a uniform, dense, close, imbricating investment of squames.

Wings as a rule—to which, however, there are not a few exceptions—spotted.

In repose the body, as a rule, is inclined at a strong angle with the resting surface.

The larva (Fig. 13) floats in a horizontal position, being moored to the surface-film by fan-like tufts of scales situated in lateral series on the dorsal surface of a varying number of the abdominal segments. The tracheæ do not pass into a breathing-tube, but open in a hollow at the base of a papilla on the dorsal surface of the 8th abdominal segment. The larva is further characterised (Fig. 13) by the clypeal hairs, which may be either simple, or branched; by the row of branched or plumose frontal hairs placed between and slightly behind the antennæ; and by the long *feather-like* hairs on the sides of the thorax and anterior abdominal segments.

It is convenient to divide this genus into seven subgenera or twelve series, paying due but not exclusive attention to Theobald's criterion of scale-structure. With reference to the scale-test in its more minute applications, it would be well if collectors would carefully notice whether or not the distribution of the abdominal scales and the breadth of

the thoracic scales ever show any periodic or seasonal variation.

Synopsis of Subgenera of Anopheles.

A. The covering of the scutum consists mainly either of hairs or of *narrow* scales. In any ambiguous case the palpi are slender (*i.e.*, are not shaggy with outstanding scales) = 1.

B. The covering of the scutum consists mainly of recumbent, broadish or spindle-shaped scales. In any ambiguous case palpi shaggy = 4.

1. Abdomen either without scales, or with some inconspicuous narrow scales on the genital lobes and terminal segment, or with a tuft of scales on the ventral surface of the penultimate segment = 2.
   Abdomen with an outstanding tuft of stiff and slender scales of extraordinary length on each side of every segment. (Chiefly hairs on the scutum) = *Christya.*
   Abdomen with conspicuous scales on several segments, some of them sometimes forming regular, outstanding tufts; wing-scales broad. (Chiefly hairs on the scutum) = *Arribalzagia.*

2. Wings either not spotted at all, or having a few dark spots formed merely by clumps of scales, or if spotted in contrasted colours then there are not more than two distinctly formed spots of colour on their anterior edge. In any ambiguous case (*e.g.*, where a spot at the tip of the wing is counted as anterior) then the palpi are shaggy with outstanding scales. (Chiefly hairs on the scutum) = 3.
   Wings much spotted in contrasted colours, their anterior edge barred or banded with numerous alternate dark and light spots or streaks. In any ambiguous case the palpi are not shaggy. Inconspicuous narrow scales occasionally present on the terminal abdominal segment and genital lobes. (Either hairs or narrow scales on scutum) = * *Myzomyia.*

3. No scales on the abdomen (*very rarely* a few scattered on the genital lobes) = *Anopheles.*
   Abdominal scales present, usually as a small outstanding tuft on the ventral surface of the penultimate segment, rarely as a uniform covering to the terminal segment and genital lobes = *Myzorhynchus.*

4. The predominant scales of the head are of the "upright forked" kind = § *Nyssorhynchus.*
   The predominant scales of the head are not of the "upright forked" kind = *Chagasia.*

* *Myzomyia* Series.

a. The covering of the field of the scutum consists mainly of hairs = *Myzomyia.*

b. The covering of the scutum consists mainly of narrow scales = "*Pyretophorus.*"

§ *Nyssorhynchus* Series.

a. Abdominal scales present on some of the distal segments = *Nyssorhynchus.*
b. Abdominal scales scattered over all the segments = "*Neocellia.*"
c. Abdominal scales fairly abundant on all the segments, and also forming regular outstanding tufts which may be either lateral or ventral = "*Cellia.*"

The following forms are not included in the above synopsis :—

1. *Aldrichia error*, Theobald. One specimen from India, now in the British Museum. As it stands it is a composite specimen, consisting of the head, thorax, and wings of a *Myzomyia rossii* to which the dark scaly abdomen of some other species of mosquito has been attached with gum.

2. *Bironella gracilis*, Theobald. Three males from New Guinea, now in the Budapest Museum. According to Theobald the palpi are shorter than the proboscis, the 2nd marginal cell of the wing is extremely small, the wings are not spotted, and the covering of the thorax and abdomen consists of hairs.

3. *Dactylomia*, Newstead and Carter. One specimen from Ceylon. Said to resemble a *Myzomyia* except for having a pair of projecting finger-like thoracic lobes.

Subgenus ANOPHELES (*sensu restricto*).

Including *Anopheles* and *Stethomyia* and part of *Cyclolepidopteron* of Theobald's Monograph ; and *Neostethopheles* and *Patagiamyia*, James.

There may be some narrow scales on the pronotum and front edge of the scutum, but the vestiture of the scutum consists mainly of hairs, which are sparse. There may, very rarely indeed, be a few inconspicuous narrow scales on the genital lobes, but the vestiture of the abdomen also consists of sparse hairs. The wings are either unspotted, or have a few dark spots formed by clumps of scales; or they may have a few colour-spots, in which case not more than two of these—distinctly formed—are present on the anterior (costal) edge. The wing-scales are usually, but not always, long and narrow. Palpi usually, but not always, slender.

The subgenus is represented in all the great zoogeographical regions, but only just enters the Ethiopian region.

1. *European Species.*

Anopheles bifurcatus, L. A large species, in which there are no spots on the wings, and no bands on the palps and legs.

Anopheles nigripes, Staeger. A small and very dark species with no spots on the wings, but with traces of two grey bands on the palps.

Anopheles maculipennis, Meigen. A large and common species with four large black spots, formed by clumps of scales, on the wings.

2. *African Species.*

Anopheles algeriensis, Theobald. Found in Algiers. Like *A. bifurcatus* (see above) but lighter in colour and smaller: probably a variety.

Anopheles smithii, Theobald. Found in Sierra Leone. The wings are not spotted and the legs are not banded, but the palps have three narrow pale rings. Mr Theobald speaks of a variety of this species which has "traces of three minute costal spots."

Anopheles maculipennis, Meigen (see above), is found in North Africa.

Anopheles wellcomei, Theobald. A small species common in the Sudan. The wings are spotted, having several black spots in the field and two yellow spots on the front edge. The extreme tips of the tarsal segments are yellow.

3. *Asiatic Species.*

Anopheles aitkenii, James. From the Malabar coast and the Darjiling Terai. The wings are not spotted and the palps and legs are not banded; and the species if it be truly distinct, differs from *A. bifurcatus* (see above) in the comparatively small size of the 2nd posterior cell.

Anopheles culiciformis, James and Liston. From the Malabar coast. Appears to differ from *A. aitkenii* chiefly in its larger size and by its carriage when at rest, which is *Culex*-like.

Anopheles fragilis, Theobald (= *Stethomyia fragilis*, Theobald). From jungle near Kuala Lumpur. Wings brownish, not spotted. In the female the scales of the head are sparse; in the male there are some flat scales between the eyes. Palpi and legs not banded, the legs remarkably long and slender. A very slender mosquito which reposes like a *Culex*.

Anopheles pallidus, Ludlow (= *Stethomyia pallida*, Lud-

low). From jungle in the Philippines. Seems to be identical with *Anopheles fragilis.*

Anopheles barianensis, James. From India. May possibly be identical with *Anopheles fragilis.*

Anopheles immaculatus, Theobald. From Madras. The wings, which are yellowish, are not spotted. The palps are comparatively short, and have two narrow white bands and a broadly white tip. The tips of the tarsal segments are more or less distinctly pallid.

Anopheles maculipennis, Meigen (see above), has been found in Palestine.

Anopheles lindesayi, Giles. From Northern India. The wings have spots in the field and one yellow spot on the front edge, near the tip. The palpi are not banded. The femur of the hind legs has a broad white band near the middle.

Anopheles lindesayi var. *maculatus*, Theobald. From Kurseong. Differs from typical *A. lindesayi* in having four black spots in the field of the wing arranged much as in *A. maculipennis.*

Anopheles gigas, Giles. From Peninsular India and Ceylon. Wings with black spots in the field and with two large and conspicuous yellow spots in the front edge. The palps are not banded. The bases of the tarsal segments are more or less pallid.

Anopheles wellcomei, Theobald (see under African species), is said by Theobald to occur near Aden.

Anopheles formosus, Ludlow. From the Philippine Islands. Perhaps belongs to this group.

Anopheles separatus, Leicester (=*Myzorhynchus separatus*, Leicester). From Kuala Lumpur, Malay States. Palpi with two ill-defined dirty-white rings and white tip. Legs brown, sometimes plain, sometimes with pale bands at the first three intertarsal joints. Wing-scales dark brown and yellowish; two small spots on the front edge.

4. *North American Species.*

The clear-winged species *Anopheles bifurcatus*, L., and *nigripes*, Staeger, and the spotted-winged species *Anopheles maculipennis* (see all under European species) occur in North America.

Anopheles barberi, Coquillett. From Maryland. Superficially has a close resemblance to *A. bifurcatus*, but has the head covered with simple hairs, and has plumose lateral hairs on the 6th abdominal segment.

Anopheles perplexens, Ludlow. From Pennsylvania. The scales of the wing are all dark except for a few minute yellowish spots, namely two on the front edge, one in the wing-fringe at the end of the 3rd longitudinal vein, and one on each fork of the 4th vein. The extreme tip of the palps are white, and the extreme tips of the femora and tibiæ are yellowish.

Anopheles quadrimaculatus, Say, is, according to Theobald, a synonym of *A. maculipennis.*

Anopheles occidentalis, Dyar and Knab. From the Eastern States. Is perhaps only a variety of *A. maculipennis.*

Anopheles atropos, Dyar and Knab. From Florida. Like *A. maculipennis*, but smaller and having the four black spots of the wing only just suggested.

Anopheles crucians, Wiedemann. Apparently a common species. The wings are spotted, and their front edge has one pale spot. The palps have two white bands and a white tip, and the tip of the femora and tibiæ is yellow.

Anopheles punctipennis, Say. There are two yellow spots on the front edge of the wing one of them being at the tip. The wing-fringe is not spotted. The palps have two very obscure grey bands and a greyish tip. The tip of the femora and tibiæ is yellow.

Anopheles franciscanus, M'Cracken. From Texas and California. Seems to differ from *A. punctipennis* in having a series of yellow spots on the wing-fringe. From the *description* it is not easy to distinguish this proposed species from the South American *A. pseudopunctipennis.*

5. *Neotropical Species (Central and South America and West Indies).*

Anopheles eiseni, Coquillett. Gautemala. Front edge of the wing not spotted.

Anopheles pseudopunctipennis, Theobald. Grenada. The wing has two yellow spots on the front edge, and a series of

yellow spots in the fringe. Palpi with two yellow bands and a yellow tip. May possibly be identical with *A. franciscanus.*

Anopheles vestitipennis, Dyar and Knab. West Indies. The wing is black, but the costa and some of the longitudinal veins are finely spangled with gold, the legs also are spangled in the same way. Palpi and tarsi of front and hind legs banded. There are some scattered scales on the genital lobes.

Anopheles strigimacula, Dyar and Knab. Mexico. Tarsi banded, some of the segments of the legs speckled. Veins of wing white with black dots and spots, the last vein with three black dashes; no spot at the tip of the wing.

Anopheles apicimacula, Dyar and Knab. Mexico, Central America, and Trinidad. As *strigimacula*, but with a black costal spot at tip of wing.

Anopheles punctimacula, Dyar and Knab. Panama. As *strigimacula*, but the last longitudinal vein with a row of black dots. Seems to be hardly different from *A. strigimacula.*

Anopheles tibiamaculatus, Neiva (=*Myzorhynchella tibiamaculata*, Neiva). Brazil. Terminal third of palpi white. Wings with a few yellow spots; the front edge with two small yellow spots and a yellow tip, the inner of the two spots not breaking the costa. Except for some scales at its front edge, the scutum is covered with hairs, so that this species cannot be included in the same group with *Myzorhynchella.*

Anopheles grabhamii, Theobald (= *Cyclolepidopteron*, Theobald). Jamaica and Cuba. Palpi very shaggy, not banded. Some of the segments of the legs mottled yellow and brown. Wings with remarkably broad scales, some of which are very broadly foliaceous and are clumped together to form conspicuous black spots. Except for two yellow spots, one of which is at the tip of the wing, the costa is black. Three well-defined brown spots on the scutum. As there are no scales whatever on the abdomen, this species cannot be graded with the other species that bear the name "Cyclolepidopteron."

Anopheles nimbus, Theobald (=*Stethomyia nimbus*, Theobald). Brazil and British Guiana. Wings brown, not spotted. Palpi and legs not banded, the legs very long and

slender. A small patch of flat scales between the eyes. Scutum with a conspicuous median white stripe. Rests like a *Culex*.

6. *Australian Species.*

Anopheles corethroides, Theobald. Wings not spotted. Palpi and legs not banded. Three brown lines on the scutum—one anterior and median, the others posterior and lateral. South Queensland.

Anopheles atratus, Skuse (=*Pyretophorus atratus*, Theobald). Wings with about six black spots formed by clumps of scales; the fringe at the tip of the wing is light grey, and there are a few small grey spots in the wing-fringe proper. Palpi and legs nearly black, the tip of the palpi pallid. Scutum with some short, yellow, hair-like scales interspersed among the sparse long hairs.

Subgenus MYZORHYNCHUS, Blanchard (Gr. μύζειν=to moan, or to suck; ῥύγχος=beak).

Including *Myzorhynchus* and *Lophoscelomyia* of Theobald's Monograph.

There are no true scales in the field of the scutum, though there may be some on its front edge and on the pronotum. Abdominal scales are restricted to a single outstanding tuft on the ventral surface of the penultimate segment, except in one species (=*Lophoscelomyia*) in which the terminal segment is covered with narrow scales. Wings very dark, though not without spots; their front edge (costa) never has more than two spots, exclusive of a spot which may be present in the fringe at the tip of the wing; these two spots are usually small. The wing-scales are usually spindle-shaped. The maxillary palps are always shaggy with scales, though this character taken singly is by no means diagnostic.

One species is Palæarctic and one is Australian; the others are found only in the Oriental and Ethiopian regions. As a rule they are rather large, black-looking, jungle mosquitoes.

1. *European Species.*

Anopheles (*Myzorhynchus*) *pseudopictus*, Grassi. Palpi black, with three white bands. The first 4 tarsal seg-

ments are pale at tip. Costa with two pale spots in the distal half; wing-fringe with a pale spot at the ending of the lower fork of the 5th longitudinal vein. Italy and Hungary in open country.

2. *African Species.*

Anopheles (*Myzorhynchus*) *strachani*, Theobald. Palpi black. Legs deep brown with faint bands at the intertarsal joints. Wings black, except for three small yellow spots, one of which is on the costa. From Lagos, West Africa.

Anopheles (*Myzorhynchus*) *paludis*, Theobald. Palpi black, with four narrow white rings. In the hind leg the last 3 tarsal segments and part of the one preceding them are snow-white. Wing-scales black, with some admixture of yellow; costa with two small yellow spots. Common in Africa south of the latitude of the Sudan.

Anopheles (*Myzorhynchus*) *mauritianus*, Grandpré, is probably a variety of *paludis*. The tarsi of the hind leg are coloured in the same way, except that there is a narrow black band at the base of the 3rd segment; the banding of the palpi varies considerably. Common in Africa, south of Egypt; also in Mauritius and Madagascar.

Anopheles (*Myzorhynchus*) *constani*, Laveran, and *ziemani*, Grünberg, are probably this species.

3. *Asiatic Species.*

Anopheles (*Myzorhynchus*) *sinensis*, Wiedemann. Palpi dark, with white tip and two white rings. Legs brown, most of the tarsal segments with pale base. Wing-scales mostly dark; two small yellowish-white spots on the costa, a yellow spot in the fringe at the tip of the wing, and one in the wing-fringe proper, at the ending of the lower branch of the 5th longitudinal vein. Oriental Region generally; also Japan.

Anopheles (*Myzorhynchus*) *peditæniatus*, Leicester. From the Malay States. Is probably a variety of this species.

Anopheles (*Myzorhynchus*) *vanus*, Walker. Differs from *sinensis* in being smaller, and in having no spot in the wing-fringe proper. Oriental Region.

Anopheles (*Myzorhynchus*) *minutus*, Theobald. Palpi

with white tip and three white rings. First 3 tarsal segments with white tip. Wing-scales dark with some admixture of yellow; two small white spots on the costa; a yellow spot in the fringe at the tip of the wing, but no spot in the wing-fringe proper. Punjab and Malay Peninsula.

Anopheles (*Myzorhynchus*) *nigerrimus*, Giles. Palpi with three white bands and black tip. Some of the tarsi with pale tips. Wing-scales mostly dark; costa with two yellowish spots. India.

Anopheles (*Myzorhynchus*) *barbirostris*, Van der Wulp. Palpi all black. Tip of tibiæ and tarsi pallid. Wing-scales mostly black; costa with two small yellow spots, one of which is at the tip of the wing; wing-fringe with one distinct spot, at the end of the 3rd longitudinal vein. Oriental Region generally; Japan.

Anopheles (*Myzorhynchus*) *pseudobarbirostris*, Ludlow. From the Philippine Islands. Seems to differ from *barbirostris* chiefly in having the femora and tibiæ speckled with white. It may be a variety.

Anopheles (*Myzorhynchus*) *umbrosus*, Theobald. From the Malay Peninsula. Differs from *barbirostris* in having only one costal spot, situated near the tip of the wing; there is also a spot in the wing-fringe, at the ending of the lower branch of the 2nd longitudinal vein.

Anopheles (*Myzorhynchus*) *albotæniatus*, Theobald. From the Malay Peninsula. Palpi all black. In the hind leg the tibia and first 2 tarsal segments all have a white spot or narrow band at both ends, the next 2 tarsal segments have a broad white band at both ends, and the terminal segment is white. The wings are like those of *barbirostris*, except that there is no spot in the wing-fringe proper.

Anopheles (*Myzorhynchus*) *asiaticus*, Theobald (= *Lophoscelomyia asiatica*, Theobald). Differs from all other species of the *Myzorhynchus* group in having (1) the whole of the last abdominal segment covered with long narrow scales; and (2) a large outstanding tuft of black scales and white scales at the distal end of the hind femora; and in not having the usual ventral tuft of scales on the penultimate abdominal segment. The shaggy palpi are not banded.

The wing-scales are mostly dark coloured, there being no conspicuous spots in field or fringe, but there are two conspicuous yellow spots on the costa. Malay Peninsula.

4. *Australian Species.*

Anopheles (*Myzorhynchus*) *bancroftii*, Giles. Palpi and legs black, the tarsal segments pallid at the extreme tip. Wings black, though there are some scattered white scales; costa black with two white breaks, one of which is at the tip of the wing.

Subgenus CHRISTYA, Theobald.

As in the subgenera *Anopheles*, *Myzorhynchus*, and *Arribalzagia*, the main vestiture of the scutum consists of sparse hairs. On either side of every segment of the abdomen there are regular outstanding tufts of stiff and very slender scales of extraordinary length. In other respects the single species—found in Eastern Africa—which is separated to form this "subgenus" closely resembles the species of *Myzorhynchus*.

Anopheles (*Christya*) *implexus*, Theobald. Uganda. On the last segment of the abdomen and on the genital lobes there are some ordinary scales. The length of the slender scales of the lateral tufts is about two-thirds the breadth of the abdomen. Palps shaggy, with three white bands and white tip. Femora and tibiæ barred with white; tarsal segments of front and middle legs white at base; in the hind legs the greater part of the 2nd tarsal segment, all the 3rd and 4th segments, and the proximal half of the 5th are white. The wings have a few small yellow spots in the field and fringe; the costa has a pale base and two large yellow spots with a small yellow spot between them.

Subgenus ARRIBALZAGIA, Theobald.

Including *Arribalzagia*, *Manguinhosia*, *Kerteszia*, and part of *Cyclolepidopteron* of Theobald's Monograph.

There may be some narrow scales on the pronotum and front edge of the scutum, but the vestiture of the scutum consists mainly of hairs. Conspicuous broad scales are

present on some or all of the segments of the abdomen, and though they seldom form a close investment they often stand out as prominent tufts or broken bands. The wings though decidedly spotted have a dark cast, owing to predominance of blackish scales, and in several of the species there are large black spots on the front edge, the colour of which, though mainly due to scales, is partly due to staining of the wing itself. The wing-scales are broad.

The species are restricted to South America.

Anopheles (*Arribalzagia*) *maculipes*, Theobald. Trinidad and Brazil. Genital lobes and last segment of the abdomen thickly covered with broadish scales; on every other segment of the abdomen, except the first, there are, besides scattered recumbent scales, very regularly arranged tufts, or broken bands, of remarkably broad, erect scales. The wings, though largely dark scaled, are spotted with yellow scales, and all the scales are broad; at the front edge there are three black blotches—two very large, one small—the colour of which is partly contributed by a staining of the wing itself. Palps very shaggy, black, with narrow white bands and white tip. Legs dark brown, much banded and brindled with white and yellow. Three well-defined brown spots on the scutum, the largest of which invades the scutellum.

Anopheles (*Arribalzagia*) *pseudomaculipes*, Chagas, also from Brazil, is probably a variety of the above. It is said to differ in having broader wing-scales and the tarsi more spotted.

Anopheles (*Arribalzagia*) *mediopunctatus*, Theobald (= *Cyclolepidopteron mediopunctatum*, Theobald), also from Brazil, so closely resembles *Arribalzagia maculipes* as to raise the suspicion that the two may be seasonal forms of the same species. In the specimens preserved at the British Museum the only differences to be detected are (1) in the palps, which are not, or are very obscurely, banded; and (2) in some of the scales, both of the abdomen and wings, being broadly foliaceous.

Anopheles (*Arribalzagia*) *intermedius*, Chagas (= *Cyclolepidopteron intermedium*, Chagas), also from Brazil, is said to differ from *mediopunctatus* in not having bands on the palps. Possibly all four "species" are local or seasonal forms of one species.

Anopheles (*Arribalzagia*) *lutzii*, Chagas (=*Manguinhosia lutzii*, Chagas). Brazil. The last 2 segments of the abdomen and the genital lobes are covered with broad white scales, and a few scales of the same kind are scattered on some of the other segments. Wing-scales lanceolate, brown and white, the former forming spots; on the front edge of the wing there are two large black blotches and two small black spots, the colour of which is partly contributed by a staining of the wing itself. Legs yellowish-brown, the tips of the tibiæ and the intertarsal joints pale. Scutum with three well-defined brown spots, the largest of which invades the scutellum.

Anopheles (*Arribalzagia*) *bolivensis*, Theobald (=*Kertészia bolivensis*, Theobald). Bolivia. The abdomen is "clothed with rather irregular large black scales." Palps black and shaggy, with two narrow yellow bands and yellow tip. The proximal 2 or 3 tarsal segments are banded or spotted. Five yellow spots on the front edge of the wing, one of them being at the tip. The scutum has four brown stripes—two straight down the middle and a somewhat sinuous one on either side.

Subgenus MYZOMYIA, Blanchard (Gr. μύζειν=to moan, or to suck; μυῖα=fly).

Including *Myzomyia*, *Feltinella*, *Neomyzomyia*, and *Pyretophorus* of Theobald's Monograph, and *Nyssomyzomyia*, James.

There are usually some distinct scales on the pronotum and front part of the scutum, but the main vestiture of the scutum consists either of hairs (series *Myzomyia*) or of narrow curved scales (series *Pyretophorus*). There may be a few narrow scales on the genital lobes, or even on the terminal segment of the abdomen, but the main vestiture of the abdomen consists of hairs. The wings are almost always profusely mottled or spotted, and the costa is barred or banded with numerous alternate dark and light spots or streaks. The wing-scales are generally narrow. Palpi slender.

The species are usually small, are numerous, and are most abundant in the Ethiopian and Oriental regions, although they are also represented in the Palæarctic Region and just

make an appearance in the Neotropical Region. It is doubtful whether all the species that have been described are valid.

1. *European Species.*

Anopheles (*Myzomyia*) *hispaniola*, Theobald. Palpi brown, with three pale bands. Legs deep brown, not banded, but tips of femora and tibiæ pale. Two brown spots on the scutum. Costa with five black spots; wing-fringe with several pale spots. Spain (and Teneriffe).

Anopheles ("*Pyretophorus*") *superpictus*, Grassi. Palpi with three pale bands. All the tarsi with pale ends. Costa with four black spots; wing-fringe not spotted. South Europe.

Anopheles ("*Pyretophorus*") *cardamatisii*, Newstead and Carter. Said to be distinguished by the great length and slenderness of the proboscis and palpi of the female. Athens.

2. *African Species:* (a) *Palæarctic Region.*

Anopheles ("*Pyretophorus*") *myzomyfacies*, Theobald. Palpi with three pale bands and black tip. Legs brown; in the hind legs the tip of the tibia and of all the tarsal segments pale. Costa with four black spots, and two very small ones at base. Algeria.

Anopheles ("*Pyretophorus*") *chaudoyei*, Theobald. Differs from the last species in having the legs entirely brown. Algeria.

Anopheles ("*Pyretophorus*") *sergentii*, Theobald. Palpi with two white bands and white tip. Legs brown, not banded. Wings dark; costa with four black spots. Very much like *A. palestinensis* (see below), except that the black spots of the costa are much larger than the pale spots with which they are alternate.

3. *African Species:* (b) *Ethiopian Region.*

Anopheles (*Myzomyia*) *funestus*, Giles. Palpi with two white bands and white tip. Legs dark brown or black, not banded. Costa black, with four small yellowish spots, not including two inconspicuous dots at the base; wing-fringe spotted. A very common species, occurring up to 5000 feet.

Anopheles (*Myzomyia*) *longipalpis*, Theobald. From British Central Africa. Is described from a single female and is not markedly different from the preceding.

Anopheles (*Myzomia*) *pyretoporhorrides*, Theobald. Palpi with three white bands and white tip. Legs brown; all the femora, tibiæ, and 1st tarsal segments speckled. Wings dark; costa with five black spots, of which the first is small and the third is large. Pretoria.

Anopheles (*Myzomyia*) *nili*, Theobald. Palpi and proboscis brown with pale tip. Legs brown, not banded. Wings dark; costa with three small yellowish spots. Nile provinces.

Anopheles (*Myzomyia*) *rhodesiensis*, Theobald. Palpi with two or three yellowish rings and dark tip. Legs dark brown, not banded. Wings dark; costa with three small white spots and a yellow spot at the tip of the wing; wing-fringe not spotted. Uganda, Congo Free State, South Africa.

Anopheles (*? Myzomyia*) *impunctus*, Dönitz. Described from a single specimen from Lower Egypt.

Anopheles (*Myzomyia*) *pallidopalpis*, Theobald (= *Feltinella pallidopalpis*, Theobald). Only the male known. In the palps the tips of the first 2 segments and the greater part of the last 2 segments are golden-yellow. Legs brown, not banded. Wings with few spots in the field, none in the fringe; costa with four small yellowish spots.

Anopheles ("*Pyretophorus*") *costalis*, Loew. Palpi with two narrow white bands and white tip; occasionally the white tip may be subdivided so as to form an extra white band. Femora and tibiæ (and sometimes to some extent the first of the tarsal segments) much brindled or speckled with yellow. The joints between the tarsal segments are yellow, this being most marked in the front legs. Costa black, with five or six small, irregular, yellow spots. Common in Tropical Africa, also in Madagascar and Mauritius.

Some specimens of this species have the scales of the scutum fairly broad, and this and the speckling of the legs may give a suggestion of *Nyssorhynchus*; but the slender palpi are sufficient to distinguish the present species.

Anopheles ("*Pyretophorus*") *ardensis*, Theobald. From Natal. Is only a variety of *costalis*; the 1st tarsal segment is as much speckled as the tibia and femora.

Anopheles ("*Pyretophorus*") *pseudocostalis*, Theobald. From West Africa. Differs from *costalis* in not having the legs speckled.

Anopheles ("*Pyretophorus*") *marshallii*, Theobald. Palpi with a narrow white band, a broad white band, and a broadly-white tip. Legs dark brown with the extreme tips of the segments slightly paler. Costa black, with five or six extremely small yellowish-white spots. Congo Free State.

Anopheles ("*Pyretophorus*") *cinereus*, Theobald. A large form. Palpi with three white bands and pale tip. Legs deep black; a white spot at the tip of femora and tibiæ; tips of the tarsal segments yellowish-white. Costa with four large black spots and with two small ones at the basal end; fringe at tip of wing yellow and black. South-west and Central Africa.

Anopheles ("*Pyretophorus*") *austenii*, Theobald. Palpi with two white bands—one narrow, the other broad—and a broadly-white tip. Legs black, the tips of nearly all the segments white. Costa black, with three small white spots. Scutum and scutellum with snow-white scales. Angola.

Anopheles (= "*Pyretophorus*") *pitchfordii*, Power. Scutum and scutellum with creamy scales. Costa with four black spots alternating with four light ones. Tips of segments of legs merely pale. Uganda, Zululand.

Anopheles hebes, Dönitz, and *Anopheles merus*, Dönitz, both from East and South-west Africa, seem to be closely related to *Anopheles costalis*, Loew.

4. *Asiatic Species:* (a) *Palæarctic Region.*

Anopheles ("*Pyretophorus*") *palestinensis*, Theobald. Palpi with two white bands and white tip. Legs brown, with pale bands at the femoro-tibial and tibio-tarsal joints. Costa with four black spots. Cyprus and Palestine.

Anopheles ("*Pyretophorus*") *nigrifasciatus*, Theobald. Palpi with three pale bands and black tip. Legs brown, not banded; tip of femur and tibia of hind legs pale. Costa with four small black spots and two basal black dots. Cyprus and Baluchistan. From the description of *Anopheles* (*Myzomia*) *azriki*, Patton (1905), from the Aden district, *A. nigrifasciatus* (1907) can not be distinguished. The Oriental

Anopheles (*Myzomyia*) *turkhudii* is also difficult to distinguish from this species.

Anopheles ("*Pyretophorus*") *nursei*, Theobald. Palpi with two obscure pale bands and somewhat pale tip. Legs entirely brown. Can hardly be distinguished from *nigrifasciatus.*

5. *Asiatic Species:* (b) *Ethiopian Region.*

Anopheles (*Myzomyia*) *azriki*, Patton (1905). See above.

Anopheles (*Myzomyia*) *d'thali*, Patton. Palpi with two white bands and dark tip. Legs brown with faint yellow bands at all the joints. Costa with four black spots; wing-fringe dark. Aden District.

Anopheles (*Myzomyia*) *jehafi*, Patton. From the Aden District. Is considered by Theobald to be the same as *Anopheles* ("*Pyretophorus*") *cinereus.* (See above, African species.)

6. *Asiatic Species:* (c) *Oriental Region.*

Anopheles (*Myzomyia*) *rossii*, Giles. Palpi with two narrow white bands and white tip. Legs brown; intertarsal joints with pale bands, most conspicuous in front legs. Front edge of wing with one or two black specks near the root and a small black spot near the tip of the wing, and between them three large black spots, the middle one of which is of a squat T-shape; wing-fringe spotted. There are some narrow scales on the genital lobes, and—few, scattered, and inconspicuous—on the terminal abdominal segment, as in several other species of the subgenus.

Anopheles (*Myzomyia*) *ludlowii*, Theobald. From the Philippines and Malay Peninsula. Is said to differ from *rossii* in having the legs spotted; but Indian specimens of *Myzomyia rossi* may have speckled legs.

Anopheles (*Myzomyia*) *indefinatus*, Ludlow, and *mangyanus*, Banks, from the Philippines; and *aconitus*, Dönitz, from Sumatra, are perhaps only varieties of *rossii.*

Anopheles (*Myzomyia*) *listonii*, Liston. Palpi with two white bands and white tip. Legs dark brown, not banded. Costa black, with four yellow spots; wing-fringe with five light spots; 3rd longitudinal vein with white scales much predominating. India and Malay Peninsula.

Anopheles (*Myzomyia*) *culicifacies*, Giles. Differs from *listonii* in having chiefly black scales on the 3rd longitudinal vein, and only two light spots in the wing-fringe. Rests like a *Culex*. India and Burma.

Anopheles (*Myzomyia*) *leptomeres*, Theobald. A very small form, probably an individual variety of *culicifacies*. India.

Anopheles (*Myzomyia*) *turkhudii*, Liston. Palpi with three white bands and black tip. Legs dark brown, with the tips of the femora and tibiæ pale. Costa with four yellow spots, not including two specks near the root of the wing; wing-fringe spotted. India.

Anopheles (*Myzomyia*) *thorntonii*, Ludlow. Basal half of palpi brown with two narrow white bands, distal half white with two narrow brown bands. Basal half of proboscis brown, distal half yellow with brown tip. Legs brown, speckled with white, intertarsal joints with white bands. Wings much spotted; costa dark, with four spots, not including two or three specks at base. Philippine Islands.

Anopheles (*Myzomyia*) *albirostris*, Theobald. Palpi with two white bands—one narrow, the other broad—and white tip. Greater part of distal half of proboscis white. Legs brown, the tips of the segments pale. Malay Peninsula.

Anopheles (*Myzomyia*) *deceptor*, Dönitz. Palpi white from about the middle of the 2nd joint, with two narrow dark rings in the white portion. Terminal half of proboscis whitish. Sumatra.

Anopheles (*Myzomyia*) *elegans*, James. A thick outstanding patch of scales at the postero-lateral angle of the head on either side. Palpi with three white bands and white tip. Two dark spots on scutum. Legs brown, speckled with white; white bands at the intertarsal joints; a considerable part of the distal half of the hind tibiæ snow-white. Costa with two small and four large yellow spots. India.

Anopheles (*Myzomyia*) *leuçophyrus*, Dönitz. From Sumatra. Is probably identical with *elegans*; if this be so, the name *leucophyrus* has precedence.

Anopheles ("*Pyretophorus*") *jeyporensis*, James. Palpi with two white bands and white tip. Legs black, the extreme tips

of most of the segments white. Costa with four yellow spots. Central and South India.

Anopheles ("*Pyretophorus*") *minimus*, Theobald. Palpi banded. Legs all brown. Costa with three yellow spots and yellow tip. Hongkong; Philippines.

7. *Neotropical Species.*

Anopheles (*Myzomyia*) *lutzii*, Theobald. Palpi black, with two narrow white bands and white tip. Coxæ and trochanters white, tibiæ with a patch of white on the under side, 1st tarsal segment of front and middle legs banded alternately dark and white, next 3 tarsal segments of front legs and all those of hind legs with white ends. Costa with five pale spots, two of which, near the root of the wing, are small. Rio de Janeiro.

Anopheles bellator, Dyar and Knab. Palpi all black. Legs banded. Trinidad.

Subgenus NYSSORHYNCHUS, Blanchard
(Gr. νύσσειν = to prick; ῥύγχος = beak).

Including *Nyssorhynchus* of Theobald's Monograph, and *Calvertina*, Ludlow.

Series I.—*Nyssorhynchus* Restricted.

The scutum is fairly well covered with short, more or less recumbent, *scales* of considerable breadth, which cannot be mistaken for "hair-like scales" or hairs by a novice. Narrow scales are also usually present on at least the dorsal surface of some of the abdominal segments, commonly on the segments behind (and including) the 4th, sometimes on the terminal segment and genital lobes only; but abdominal scales may occasionally be altogether absent. The wings, though they have a dark cast, are much speckled, and there are always numerous spots on the costa; wing-scales fairly broad. The palpi are usually shaggy with scales, and it is very common for the legs to be profusely spotted, speckled, or finely barred with white, and for some of the tarsal segments of the hind legs to be white.

The species are found in the Ethiopian, Oriental, and Australian regions.

As a "subgenus" *Nyssorhynchus* cannot be sharply differentiated from *Neocellia* and *Cellia*, and but for my inveterate reluctance to meddle with names that have become generally current I should unite the three "subgenera."

1. *African Species.*

Anopheles (*Nyssorhynchus*) *maculipalpis*, Giles. Mauritius, West Africa, and South Africa. Palpi black, with a few white spots, a narrow white band, and two broad white bands, one of which is terminal. Legs black, with abundant and regular white bars; in the hind legs the 3rd, 4th, and 5th tarsal segments, and the terminal half of the 2nd are white. Wings dark, with white spots, four or five of which, of very small size, are on the costa. Abdominal scales confined to the terminal segment and genital lobes.

Anopheles (*Nyssorhynchus*) *pretoriensis*, Theobald. Transvaal and Natal, is perhaps only a variety of *maculipalpis*, from which it differs in the following not very constant points:—(1) the palps, though banded in the same way, are not spotted; (2) the 1st tarsal segment of the hind leg has a broad white terminal band, and the first of the three white segments has a black basal band.

Anopheles (*Nyssorhynchus*) *aureosquamiger*, Theobald (=*Pyretophorus aureosquamiger*, Theobald). Transvaal. Palpi with three white bands and white tip. Legs deep brown, profusely spotted with yellowish-white; in the hind legs there is a white spot at the tip of the 1st tarsal segment, a broad white band at the distal end of the 2nd, and the greater part of the 3rd and all of the 4th and 5th are white. Wings dark; costa black, with three small white spots, not including a minute spot on the tip. In the only perfect specimen at the British Museum there are no abdominal scales at all; but the scales of the scutum and scutellum are short broad elliptical scales, and the species is undoubtedly as closely as possible related to *maculipalpis* and *pretoriensis*.

Anopheles (*Nyssorhynchus*) *brunnipes*, Theobald. Angola. Palpi with two narrow white bands and broadly white tip. Legs dark brown, not speckled. Costa black, with two very small yellowish-white spots followed by three larger ones. No abdominal scales at all.

2. *Asiatic Species:* (a) *Ethiopian Region.*

Anopheles (*Nyssorhynchus*) *tibani*, Patton. From the Aden District. Palpi black, with two or three white bands and white tip. Legs black with many white spots, the "last $2\frac{1}{2}$ or $2\frac{3}{4}$" tarsal segments of the hind legs white. Wings much spotted; costa with six dark spots. A few scales on the last abdominal segment.

3. *Asiatic Species:* (b) *Oriental Region.*

Anopheles (*Nyssorhynchus*) *maculatus*, Theobald. Palpi black, with three white bands and white tip. Legs brownish-black to brown, sparsely and very inconspicuously speckled; in the hind legs the first three tarsal segments have an increasingly broad terminal white band, the 4th segment is white with a dark band across its middle third, and the 5th segment is entirely white. Costa with two very small and four large black spots. Northern India, Malay Peninsula, and Hongkong.

Anopheles (*Nyssorhynchus*) *karwari*, James. Palpi black, with three white bands and white tip. Legs not speckled, though many of the tarsal segments have white tips; in the hind legs the last tarsal segment is white. Costa with two small black spots and four large ones. Abdominal scales confined to the terminal segment and genital lobes. Karwar and Kuala Lumpur.

Anopheles (*Nyssorhynchus*) *theobaldii*, Giles. Palpi black, with three white bands and white tip. Legs profusely speckled; in the hind legs the 1st and 2nd tarsal segments have a broad white terminal band, the 3rd segment is white with a broad dark basal band, and the 4th and 5th segments are entirely white. Costa with five white spots, not including one at the tip of the wing. Some scattered scales on the 4th abdominal segment and on all the segments behind it. Northern India, Philippine Islands.

Anopheles (*Nyssorhynchus*) *fuliginosus*, Giles. Palpi black, with two white bands and white tip. Legs not speckled, though most of the segments have a white tip; in the hind legs the first 2 tarsal segments usually have a white terminal band, and the last 3 segments are usually white. Costa black,

with three or four small white spots, not including one or two minute specks near the base. Scattered scales are present on the 4th abdominal segment and on all the segments behind it. Oriental Region generally.

Anopheles (*Nyssorhynchus*) *nivipes*, Theobald. From Kuala Lumpur. Is synonymous with *fuliginosus*.

Anopheles (*Nyssorhynchus*) *indensis*, Theobald. From Peninsular India. Differs from *fuliginosus* only in having the femora and tibiæ speckled, and the abdominal scales confined to the terminal segment and genital lobes.

Anopheles (*Nyssorhynchus*) *jamesii*, Theobald. From India and Ceylon. Also very much like *fuliginosus*, but has femora and tibiæ speckled, the white spots of the costa much larger, and abdominal scales present on the segments behind the 4th but not on the 4th itself.

Anopheles (*Nyssorhynchus*) *philippinensis*, Ludlow. From the Philippine Islands. Can be distinguished from *fuliginosus* by the white spots of the costa being more than half the breadth of the dark intervals between them; (the legs are not speckled).

Anopheles (*Nyssorhynchus*) *freeræ*, Banks (=*Pyretophorus freeræ*, Banks). Seems to be a species closely related to the four preceding. From Manilla.

Anopheles (*Nyssorhynchus*) *lineatus*, Ludlow (=*Calvertina lineata*, Ludlow). Palpi with two narrow white bands and white tip. Scutum with white scales in lines. Hind legs with the 1st tarsal segment white-tipped, the second broadly white-banded terminally, the last three entirely white. Wings dark; the costa with four small white spots, not including one at the tip. Abdominal scales confined to terminal segment and genital lobes.

4. *Australian Species.*

Anopheles (*Nyssorhynchus*) *annulipes*, Walker. First segment of palpi black, with a narrow white terminal band; last 3 segments white, with a narrow black basal band. Legs profusely banded alternate black and yellowish-white. Wings very regularly and profusely speckled; costa with four black spots, not including two minute spots at the

proximal end. Abdominal scales restricted to the terminal segment and genital lobes. Australia and Tasmania.

Anopheles (*Nyssorhynchus*) *mastersi*, Skuse. Is identical with *annulipes*.

Series II.—*Neocellia*, Theobald.

The species here included resemble *Nyssorhynchus* in every particular except that the abdominal scales instead of being limited to certain segments (or absent altogether) are to be found on the dorsal surface of *all* the abdominal segments, though they are not very numerous on the most anterior segments. As the name has become current there is no harm in retaining it as "generic" in the logician's sense of the term.

The species are entirely Oriental and chiefly Indian.

Anopheles (*Neocellia*) *indicus*, Theobald. Palpi with a narrow white band, two broad white bands, and black tip. Legs speckled with white; in the hind legs the intertarsal junctions are broadly white-banded, and the last tarsal segment is all white. Costa with four black spots, not including two minute ones near root of wing. Dehra Dun (Northern India).

Anopheles (*Neocellia*) *stephensii*, Liston (= *Nyssorhynchus stephensii* of Theobald's Monograph). Palpi with a narrow white band, and two broad white bands, one of which is terminal, so that the tip is white. Legs speckled with white; in the hind legs the tarsal bands are small, and the last tarsal segment is brown. India, Philippine Islands. *Neocellia intermedia*, Rothwell is, as James suspects, this species.

Anopheles (*Neocellia*) *willmorii*, James (= *Nyssorhynchus willmorii* of Theobald's Monograph). Palpi as in *stephensii*. Legs thickly speckled with white; in the hind legs the first 2 tarsal segments both have a broad white terminal band, the next 2 are white with broad dark bands across the middle, and the 5th is entirely white. Oriental Region pretty generally. *Neocellia dudgeonii*, Theobald, from the Kangra Valley is, as James suspects, this species. *Nyssorhynchus pseudowillmorii*, Theobald, from Jalpaiguri, is also a synonym of this species.

Anopheles (*Neocellia*) *fowlerii*, Christophers, has the last 3

tarsal segments of the hind legs entirely white. Palpi with two, narrow white bands and a broad apical band. Costa with four "main" dark spots. India (Amritsar and Central provinces).

Series III.—*Cellia*, Theobald.

Including *Cellia* of Theobald's Monograph, and *Christophersia*, James.

The species here included differ from *Neocellia* only in having (in addition to the general investment of abdominal scales) outstanding tufts of scales on the abdominal segments—these tufts may be either lateral or ventral. The species are Ethiopian, Oriental, and Neotropical; one enters the confines of the Palæarctic Region, and another just extends to the Australian Region (New Guinea).

1. *African Species.*

Anopheles (*Cellia*) *pharoensis*, Theobald. Palpi brown mottled with white, and with two narrow but fairly distinct white bands and white tip. Legs mottled and banded yellow and brown; in the hind legs the banding of the tarsi is very broad and the last segment is entirely white. Costa with three large dark blotches—the middle of which is the largest—and with a small dark spot at the tip. Common in Africa from Egypt to Delagoa Bay; also Madagascar and West Africa.

Anopheles (*Cellia*) *squamosus*, Theobald. A dark species. Palpi with two narrow white bands and white tip. Scutum with white scales arranged more or less in stripes. Legs dark brown, mottled with white; in the hind legs the tarsal segments have terminal white bands, except the last, which is black. Costa black, with three distinct white spots, besides one or two minute spots at base and at tip. From Egypt to the Transvaal; Madagascar; West Africa.

Anopheles (*Cellia*) *jacobii*, Hill and Haydon. From South Africa. Is probably identical.

Anopheles (*Cellia*) *cinctus*, Newstead and Carter. Known from one incomplete specimen from West Africa. Distinguished by the very regularly arranged rings of the 1st tarsal segment ("metatarsus") of the middle and hind legs (the only legs remaining).

2. *Oriental Species.*

Anopheles (*Cellia*) *pulcherrimus*, Theobald. Palpi with three white bands and white tip. In the hind legs the end of the 1st tarsal segment is white, the 2nd tarsal segment is white except for a black band at the base, and the remaining 3 segments are white. Costa with two minute black spots followed by four large ones. India, common; also Turkestan (Palæartic).

Anopheles (*Cellia*) *kochii*, Dönitz. Palpi dirty whitish at base, yellowish-white distally, with four equidistant narrow dark brown rings. Legs much speckled and finely banded; the last 3 tarsal segments of the front and hind legs are yellowish, the last segment being often darker at the base. Abdominal tufts of scales ventral in position. Wings black and yellowish; costa with four black spots. Two dark brown spots on the scutum and one on the scutellum. Malay Peninsula and Islands.

Anopheles (*Cellia*) *punctulatus*, Dönitz. Differs from the preceding (*A. kochii*) in having all the tarsi banded, very conspicuously so in the hind legs. Malay Peninsula and Islands; (also New Guinea).

Anopheles (*Cellia*) *flavus*, Ludlow. Palpi much banded, a broad white band including the tip. Legs mottled, the tarsi with light tips; in the hind legs the tarsi are broadly white banded. Philippines.

Anopheles (*Cellia*) *hallii*, James (*Christophersia hallii*, James). The tufts of scales of the abdominal segments are in the mid-ventral line; palpi with five white bands. India.

3. *South American and West Indian Species.*

Anopheles (*Cellia*) *argyrotarsis*, Robineau-Desvoidy. Palpi black, with two narrow white bands and white tip. In the hind legs the distal half, or more, of the 2nd tarsal segment and all the 3 following segments are white. Scutum with three well-defined dark spots, the largest of which invades the scutellum. Costa black, with three small whitish spots, besides some whitish specks at the basal end. West Indies and Tropical South America.

Anopheles (*Cellia*) *albimanus*, Wiedemann, is a variety of

argyrotarsis. The stated difference is that there is a narrow black band at the base of the last tarsal segment of the hind legs, but in the London School of Tropical Medicine there is a specimen which has this band on one hind leg but not on the other. West Indies and Tropical South America.

Anopheles (*Cellia*) *braziliensis*, Peryassu. Differs from *argyrotarsis* in having the tip of the abdomen white from the presence of abundant white scales. The three spots of the costa are larger and not so sharply circumscribed. Brazil.

Anopheles (*Cellia*) *bigotii*, Theobald. Palpi with three white bands and white tip. In the hind legs the 1st tarsal segment has a white terminal band, the 2nd has a white tip, and the 3 last are white. Scutum with four longitudinal lines of light scales. Chili.

Subgenus CHAGASIA, Cruz.

Including *Chagasia* and *Myzorhynchella* of Theobald.

The scutum is covered with distinct *scales* of considerable breadth, and more or less recumbent. The vestiture of the abdomen consists of hairs, but there may be some narrow scales (inconspicuous) on the genital lobes. The wings have a dark cast, though they may be spotted; the wing-scales are of considerable breadth. The palpi are shaggy with scales, and the legs are either profusely barred, or have some of the tarsal segments white. Some of the antennal segments carry whorls of scales. On the head broad semi-procumbent scales, which are not forked, predominate, and it is this character, chiefly, that separates the subgenus from *Nyssorhynchus.*

The species are restricted to the Neotropical Region.

Anopheles (*Chagasia*) *fajardii*, Lutz. Head rather sparsely covered with broadish falcate scales and a few black bristle-like forked scales. Antennæ with particularly thick whorls of scales on the 2nd to the 7th or 8th segments. Palpi with very faint indications of pale rings at the inter-segmental joints. Legs banded in alternate rings of yellow or yellowish-white and brown, the bands of the tarsi of the hind legs being very broad. Wings dark without any noticeable spots. No scales on the abdomen. Rests like a *Culex.* Brazil.

Anopheles (*Chagasia*) *niger*, Theobald (=*Myzorhynchella nigra*, Theobald). Antennæ with distinct whorls of scales on the 2nd to the 4th or 5th segments. Palpi with four very narrow pale bands. In the hind legs the tip of the 1st tarsal segment, the distal half of the 2nd, and all the last 3 segments are snow-white. Wings dusky, hardly spotted in the field though yellow scales are present among the prevailing dark scales; front edge with four yellow spots, the two smaller of which do not break the costa. No scales on the abdomen. Brazil and Mexico.

Anopheles (*Chagasia*) *lutzianus* (=*Myzorhynchella lutzii*, Cruz, Theobald). Palpi black, except at the tips of the segments. Whorls of scales on 4 or 5 segments of the antennal flagellum. In the hind legs the tip of the 1st tarsal segment, the posterior two-fifths of the 2nd, and all the last 3 segments are white. Costa with four yellow spots. Scales on the genital lobes. Brazil.

Anopheles (*Chagasia*) *parvus*, Chagas (=*Myzorhynchella parva*, Chagas). Palpi with three narrow white bands and white tip. Whorls of scales on 4 or 5 segments of the antennal flagellum. In the hind legs the distal half of the 2nd tarsal segment and all the last 3 segments are white. Costa with three small yellow spots. Scales on the genital lobes. Brazil.

Anopheles (*Chagasia*) *nigritarsis*, Chagas. Palpi black, with the joints between the segments bronzy white. In the hind legs the distal third of the 2nd tarsal segment is whitish, the 3rd and 4th segments are both whitish with a black ring, and the 5th segment is white. Costa with five yellow spots. Scales on the genital lobes. Brazil.

CHAPTER V

Culicidæ (*continued*): Culicales, Megalorrhini, and Metanototricha

THE true Mosquitoes outside the genus *Anopheles* are here treated in three sections as follows:—

Subfamily CULICINÆ.

Section II.—*Culicales.*

Including *Culicinæ*, *Heptaphlebomyinæ*, *Dinoceratinæ*, *Ædinæ*, and *Uranotæniinæ* of Theobald's Monograph.

Mosquitoes of the *Culex* section, or *Culicales*, are distinguished from *Epialurgi* by having the posterior edge of the scutellum trilobed, from *Megalorrhini* by not having the proboscis bent like a pot-hook, and from *Metanototricha* by not having scales or bristles on the metanotum.

The scaly covering of the head shows much diversity, but the scales on the side of the head at least are flat squames. The scutum, scutellum, and abdomen are always thickly covered with scales of some kind.

The relative length of the palps is very variable; all gradations can be found, in both sexes, between palps which are "long" and palps which are "short." For instance, in *Culex* the palps are longer than the proboscis in the male and about one-sixth the length of the proboscis in the female; in *Leicesteria* and *Brevirhynchus* they are longer than the proboscis in the male, and from half to two-thirds that length in the female; in some species of *Mucidus* the female palps are about three-quarters the length of the proboscis; in *Orthopodomyia* the palps in both sexes are about two-thirds

the length of the proboscis; in *Hylecœtomyia* the female palpi are very short and the male palpi are decidedly shorter than the proboscis; in *Mimomyia* the female palpi are very short and those of the male are about two-thirds the length of the proboscis; and in *Ædes* the palps are quite short in both sexes.

The wings in the great majority of species are not spotted, but there are numerous species in which they are finely speckled, not a few in which they are coloured and mottled; and there are some in which they are distinctly spotted quite like an *Anopheles*, or even like a *Myzomyia* or a *Nyssorhynchus*.

The larva has a breathing-tube, and the lateral thoracic and abdominal hairs of the larva are not feathered.

Some recent writers on mosquitoes have broken the *Culicales* in pieces like a potter's vessel. A multitude of "genera," not to speak of "subfamilies," have been proposed, much after the arbitrary method of Procrustes. In the following synopsis I have merely taken the genera proposed by the experts, and have grouped them mainly according to the character of the scales on the several regions of the body —a method which was discovered and first made use of by Theobald. I do not, however, consider that all these genera are valid; and the "subfamilies" appear to me to be entirely artificial.

For the sake of brevity, "narrow curved scales" are referred to as "sickles," "upright forked scales" as "darts," and broad flat overlapping scales as "squames."

SYNOPSIS OF CULICALES.

(a) *Genera of the* CULEX *Type.*—Three kinds of scales—none of them specially predominant—are found on the head, namely, sickles and darts (the latter often most abundant posteriorly) on the crown, and overlapping squames on the cheeks. The scales of the scutellum are usually sickles, but in a few forms squames are also present, and very rarely squames alone. The wing-scales are usually long and narrow, but may be elliptical or obliquely spatulate. In a few species the wings are spotted as in *Anopheles maculipennis*,

or even as in Myzomyia. The palpi of the female are always very short; those of the male are almost always longer than the proboscis, but in one or two species (e.g. *Dinocerites*, a West Indian form) are very short.

(b) *Genera of the* STEGOMYIA *Type.*—Though some darts are usually present on the nape, and though a few localised sickles may sometimes be present on the head and scutellum, the predominant—sometimes the only—scales of both these regions are flat squames, which overlap like the slates of the roof and impart a very smooth appearance. The wings are never spotted, and the "lateral" scales are slender and stiff-looking. The palpi as a rule are quite short in the female and are longer than the proboscis in the male, but they may be decidedly shorter than the proboscis in the male (*e.g.* in *Hylecœtomyia*), or as much as two-thirds the length of the proboscis in the female (*e.g.* in *Brevirhynchus* and some species of *Leicesteria*), or quite short in both sexes (*e.g.* in *Harpagomyia*).

(c) *Genera of the* ÆDES *Type.*—Like the *Stegomyia* type, except that the scales of the scutellum are exclusively sickles. The palpi may be quite short in both sexes (*e.g.* in *Ædes*), or short in the female and long in the male (*e.g.* in *Pseudoskusea*), or short in the female and only about two-thirds the length of the proboscis in the male (*e.g.* in *Mimomyia*).

Many of the forms included in this series are jungle mosquitoes, and none of them are known to be of any pathogenic importance.

(d) *Genera of the* URANOTÆNIA *Type.*—The predominant —sometimes the only—scales of the head and scutellum are flat overlapping squames. There are often also many broadly-elliptical squames on the scutum. As a rule, some of the wing-scales are broad triangular leaves. The 2nd marginal cell is very small. Palpi quite short in both sexes. Small or minute insects, commonly with beautiful blue markings; usually found in jungle, and not known to be of any direct importance from the medical standpoint.

(e) *Genera of the* PSOROPHORA *Type.*—The predominant scales of head, scutum, and scutellum are elliptical squames, which are either quite flat or may be curved; they often do not overlap but have a rather scattered appearance. In

those forms where both sexes are known the palpi are short in the female and long in the male. Of no direct importance to the medical officer, but the larvæ of *Psorophora* are said to be highly predaceous.

(f) *Genera of the* MUCIDUS *Type.*—The head is shaggy with upstanding scales of different kinds, among which either coarse sickles, or broad darts, or somewhat fan-shaped scales are predominant or, at least, conspicuous. The wings are either speckled or mottled, or they may be spotted—in field, costa, and fringe—much like those of a *Nyssorhynchus;* the legs also as a rule are much mottled, brindled, or banded. The wing-scales are either broadly leaf-like, or broadly subtriangular, or shaped somedeal like the front wing of a butterfly. The palpi may be long in both sexes (*e.g.* in *Mucidus* and *Orthopodomyia*), or short in both sexes (*e.g.* in *Ædimyia*), or long in the male and shortish in the female (*e.g.* in *Mansonia*). The mosquitoes of this group seem to link the *Culicales* with the *Epialurgi*, and are on that account worthy of investigation in respect of the transmission of malaria.

(g) *Forms annectant between* CULEX *and* STEGOMYIA and ÆDES.—Though other kinds of scales are present—often localised—on the head, the predominant scales of the head are squames, which, though they overlap, do not lie flat. The scales of the scutellum are either sickles only, or sickles mingled with squames. The palpi are as a rule short in the female and long in the male, but may be (*Eumelanomyia*) shorter than the proboscis in the male, or (*Bancroftia*) about a third the length of the proboscis in the female.

The species of Culicales which at present are known to have any particular pathogenic importance belong to the *Culex*, *Stegomyia*, and *Mucidus* groups, and will be considered severally in the sequel (p. 107).

In the *Culex* group the very common tropical and subtropical house-mosquito, *C. fatigans*, is important as one of the prevalent intermediate hosts of the larva of *Filaria bancrofti.* It is also said to carry the infection of dengue.

In the *Stegomyia* group *S. fasciata* is, probably, by reason of its very wide distribution, its domestic habits, and the

vital tenacity of its eggs, and the number of different infections that it is capable of "carrying," one of the most formidable insects in existence, especially when it is remembered that in the case of one of the most appalling diseases for which it is responsible (namely, yellow fever) it can transmit the infection to its extremely resistant eggs, and so to the next generation, and perhaps even beyond.

In the *Mucidus* group two species of *Mansonia*, one of which has a very wide distribution, are important as being among the numerous nurses of *Filaria bancrofti*.

I. CULEX SERIES.

CULEX, L. (*Aporoculex*, Theob., *Culicada*, Felt, *Culicelsa*, Felt, *Culiseta*, Felt, *Microculex*, Theob., *Protoculex*, Felt). Scutellum with sickles only. The "lateral" wing-scales for the most part long and narrow. Many species, found in all parts of the world. *Culex mimeticus*, Noe, found in South Europe, India, Malay Peninsula, Ceylon, and China, has the wings spotted like an *Anopheles* (*Myzomia*).

Melanoconion, Theobald (*Neomelanoconion*, Theobald). Wing-scales broader than in *Culex*. Numerous species, small and black.

Protomelanoconion, Theobald. As *Melanoconion*, but male palpi shorter than proboscis. 1 species; West Africa.

Leucomyia, Theobald. As *Culex*, but anterior half of scutum white, and wing-scales broader. 6 species; Oriental, Australian, Ethiopian, Neotropical.

Grabhamia, Theobald. As *Culex*, but the wing-scales are broader and some of them light-coloured or white. Numerous species; found in all parts.

Pseudograbhamia, Theobald. Like *Grabhamia*, but some of the scales of the scutellum are squames. 1 species; Ceylon and South India.

Pecomyia, Theobald. Like *Pseudograbhamia*, but the squames of the sides of the head extend more on to the crown. 2 species; Oriental Region.

Neopecomyia, Theobald. Like *Pecomyia*, but the wing-scales are all dark. 1 species; West Africa.

Protomacleaya, Theobald. As *Culex*, but the scales of the middle lobe of the scutellum are squames, and the squames of the side of the head ascend higher. 2 species; North America, West Africa.

Stenoscutus, Theobald. As *Culex*, but the scales of the lateral lobes of the scutellum are squames and those of the middle lobe are elliptical and squame-like. 1 species; West Africa.

Trichorhynchus, Theobald. As *Culex*, but some small squames also occur on the front of the crown of the head, between the eyes. 1 species; Ceylon.

Reedomyia, Theobald. As *Culex*, but the scutellum is covered with squames which are usually white, and the wing-scales are broader. 8 species; India, West Africa, New Guinea.

Molpemyia, Theobald. Head scales as *Culex*; scutellum covered with white squames. The eyes are united across the crown. 1 species; Australia.

Mimeteculex, Theobald. As *Culex*, but the wings have a yellowish tinge and the costal scales are yellow, and the female palpi are longer. 1 species; Sudan.

Pardomyia, Theobald. Head scales sparse. Wings tinged with yellow and stained brown at a few small spots. Palpi of female about one-fourth length of proboscis. 1 species; Malay Peninsula and Islands.

Megaculex, Theobald. The lateral squames extend a good deal on to the dorsum of the head. Some of the wing-scales are piriform. Palpi of female more than a fourth length of proboscis. 1 species; Africa.

Oculeomyia, Theobald. Head and scutellum scales as in *Culex*. The eyes are united across the crown. 2 species; Borneo and Philippines.

Theobaldia, Neveu-Lemaire. As *Culex*, but sickles coarser, male palpi clubbed, and wing-scales clumped in places to form conspicuous black spots as in *Anopheles maculipennis*. 6 species; Europe, North Africa, North India, North America.

Pseudotheobaldia, Theobald. As *Theobaldia*, but scutellum covered with squames. 1 species; North India.

Lutzia, Theobald. As *Culex*, but sickles coarser, and the wings, costa, and wing-fringe spotted as in *Anopheles* (*Myzomia*). 1 species; Neotropical.

Lasioconops, Theobald. As *Culex*, but the abdominal segments have outstanding lateral tufts of fan-shaped scales. 1 species; West Africa.

Lophoceratomyia, Theobald. As *Culex*, but the scales of the anterior longitudinal veins are shorter and broader, and some of the proximal segments of the male antennæ have tassels of long scales and hook-like bristles. 4 species; Oriental and New Guinea.

Pectinopalpus, Theobald. 1 *male* specimen, from Ashanti. As *Culex*, but wing-scales broader, and the palpi are very hairy and are in part of their length fringed with long-stalked scales.

Tæniorhynchus, Arribalzaga. As *Culex*, but the wing-scales are long and large and bluntly elliptical or obliquely spatulate. Usually large species with banded legs and proboscis and often with somewhat speckly wings. Numerous species; Europe, America, Africa, South Asia.

Chrysoconops, Theobald. Bright yellow or purplish insects with wing-

scales as in *Tæniorhynchus*. Africa, South Asia, Australia, South America.

Trichopronomyia, Theobald. As *Culex*, but wing-scales as *Tæniorhynchus*, and proboscis of male hairy. 2 species (a single male of each known) from South America and New Guinea.

Heptaphlebomyia, Theobald. As *Culex*, but the wing-scales are somewhat broader and the crease behind the 6th longitudinal vein (which is present in most Culicines) may have a few scales. This so-called 7th scaled longitudinal vein is in different species differently described as "apparently not scaled," or as "a false nervure covered with a row of scales," or as a 7th vein "with ten to fifteen scales." 2 species from Madagascar, 1 species from Portuguese West Africa.

Dinocerites, Theobald. As *Culex*, but *the palpi are short in both sexes;* some of the wing-scales are broader; and the antennæ are of more than common length—their 2nd segment being particularly long—and in the male are not plumose. 1 species, from the West Indies, known as the "crab-hole mosquito," because it breeds in the brackish water that collects in the deep burrows of crabs. This habit may explain the length of the antennæ, which, like the elongated antennæ of certain insects that inhabit dark caves, and the streaming tactile filaments of certain fishes (e.g. *Bathypterois*) that live in the sunless depths of the ocean, may be an adaptation (on the principle of the blind man's stick) to conditions where eyesight is of no avail. This suggestion is to some extent strengthened by the fact that Knab has described another mosquito, belonging to the section *Metanototricha*, which, having the same habits as *Dinocerites*, has similar elongated antennæ.

2. Stegomyia Series.

Stegomyia, Theobald. Head and scutellum covered with imbricating squames, a clump of darts on the nape. Clypeus scaly. Male palpi longer than proboscis. Small black mosquitoes, usually with conspicuous snow-white markings. 36 species, distributed all round the globe in warm latitudes.

Quasistegomyia, Theobald. Differs from *Stegomyia* in having some squames on the after part of the scutum. 2 species; Sudan and Philippines.

Kingia, Theobald. Differs from *Stegomyia* in having some flat round squames in patches on the fore part of the scutum. 2 species; Tropical Africa and India.

Scutomyia, Theobald. Differs from *Stegomyia* in having a few sickles in the middle line of the head. 5 species; Africa, Australia, and Oriental Region.

Gymnometopa, Coquillett. Differs from *Stegomyia* in having the clypeus bare and some sickles on the scutellum. 4 species; West Indies.

Pseudocarollia, Theobald. Differs from *Stegomyia* in having some

outstanding tuft-like masses of scales on some of the abdominal segments (ventral surface). 1 species; Bengal.

Phagomyia, Theobald. Differs from *Stegomyia* in having sickles on the lateral lobes of the scutellum, and a few on the nape. 2 or 3 species; Tropical Africa and Northern India.

Polyleptomyia, Theobald. Differs from *Stegomyia* in having a few sickles on the nape, and the squames of the middle lobe of the scutellum elliptical. 1 species; West Africa.

Macleaya, Theobald. Differs from *Stegomyia* in having sickles on the lateral lobes of the scutellum and in a sagittal row on the head. 1 species; Australia.

Howardina, Theobald. Differs from *Stegomyia* in having some broadish, appressed sickles in a narrow sagittal band on the head, and a few sickles on all three lobes of the scutellum. 5 species; West Indies, India, and Ceylon.

Hylecœtomyia, Theobald. Differs from *Stegomyia* in having some sickles on the nape, on the middle of the crown, and scattered on the scutellum, and *the male palpi decidedly shorter than the proboscis.*

Ædimorphus, Theobald. Differs from *Stegomyia* in having some sickles on the head, and many more bristle-like darts. 4 species; West Africa.

Pseudograhamia, Theobald. Head and scutellum covered with squames; scutum with a median line of metallic squames. Dense outstanding scales at tibio-tarsal joint of hind legs. 1 species; South India. Male unknown.

Harpagomyia, Meijere. Head and scutellum covered with imbricating squames. Clypeus scaly. Proboscis short, thick, *hirsute*, swollen at tip. *Palpi of male* (as of female) *very short and slender.* 2 species; Malay Archipelago and West Africa.

Desvoidea, Blanchard. Head and scutellum covered with imbricating squames, also some darts on the head. Male palpi longer than the proboscis. Quite like *Stegomyia* as regards scales, but larger and not brilliantly marked and banded in white. Oriental Region generally; 5 species.

Leicesteria, Theobald. Differs from *Desvoidea* in the length of the *palpi of the female*, which *are half* (or more) *the length of the proboscis.* 2 species; Malay Peninsula and Assam.

Brevirhynchus, Theobald. Scales as in *Desvoidea. Palpi of the female two-thirds the length of the proboscis*, which is stout and sinuous. Male palpi long. 3 species; India.

Chætocrurimyia, Theobald. Head covered with imbricating squames; scales of scutellum scanty—squames and sickles. Legs remarkably spiny and bristly. 1 species; Queensland. Male unknown.

Rhachiura, Theobald. Scales as in *Desvoidea: palpi of male hardly two-thirds the length of the proboscis* and very slender; abdomen of female ending in long black hairs. 1 species; Australia.

Mimeteomyia, Theobald. 1 species; Australia; "looks like a small *Rhachiura.*" Male unknown.

Duttonia, Newstead. Head covered with squames except for some sickles behind and a row round the eyes, and numerous darts; scutellum with squames, the lateral lobes small. Male palpi long. 1 species; Africa.

Carrollia, Lutz. Head covered with squames except for a few sickles in the middle line behind and numerous darts; scutellum with squames on middle lobe only. Male palpi as long as proboscis. 1 species; Brazil.

Popea, Ludlow. Head covered with squames except for a median line of sickles and the usual darts; scutellum with squames in the middle of each lobe only; most of the abdominal segments with median ventral tufts of long scales. Male palpi long. 1 species; Philippine Islands.

? *Rhachinotomyia*, Theobald. No scales other than overlapping squames on the head and scutellum. Female palpi short. 1 species; Ceylon. The single specimen known has a long lop-sided process at the after end of the thorax, but whether this is a true chitinised appendix or not can only be determined by treatment with caustic potash. Male unknown.

Hæmagogus, Williston (including *Gaulteria*, Lutz). Head and scutellum covered with squames; scutum with elliptical squames. *Male palpi short.* Brilliantly metallic. 4 or 5 species; South America and West Indies.

Cacomyia, Coquillett. Differs from *Hæmagogus* in having the male palpi about half the length of the proboscis. 2 species; South America and West Indies.

Ficalbia, Theobald. Head and scutellum covered with squames, those of the scutellum small; head also with a few darts, posteriorly. *Male palpi short.* 4 species; Africa, India, and Ceylon.

Squamomyia, Theobald. Head and scutellum covered with squames, also some darts on the head. Clypeus densely scaled. Spindle-shaped scales on scutum. *Male palpi short.* 1 species; Burma.

Leptosomatomyia, Theobald. Head covered with squames except for some sickles in the middle line and round the eyes, and some darts; scutellum with squames on the middle lobe only. Scutum with sickles. In the male the palpi are very short, and the abdomen is very long and slender. 1 species; New Guinea.

3. ÆDES SERIES.

Ædes, Meigen. Head covered with squames, but some sickles are present in the middle line and darts also. Scutellum with sickles only. Palpi very short in both sexes. Numerous species; Europe, North America, India.

Micrædes, Coquillet. Differs from *Ædes* in the male palpi, which are about a third the length of the proboscis. 1 species; West Indies.

Verrallina, Theobald. Head covered entirely with squames, Scutellum entirely with sickles. Male unknown. 4 species; Brazil and West Indies, Africa, Malay Peninsula.

Mimomyia, Theobald. Head covered with squames; some darts but no sickles. Scutellum with sickles only. Male palpi about two-thirds the length of the proboscis. Often brightly coloured. 7 species; Africa and India.

Skusea, Theobald. Head covered with squames; some darts but no sickles. Scutellum with sickles only. Male palpi very short. 7 species; Australian and Oriental.

Pseudoskusea, Theobald. As *Skusea*, but male palpi long. 2 species; Australian.

Ludlowia, Theobald. Head covered with squames; some darts but no sickles. Scutellum with sickles only. Male palpi long and clubbed. 3 species; Philippines and Sudan.

Radioculex, Theobald. As *Ludlowia*, but the 1st longitudinal vein is sinuous and more thickly scaled than the other veins. 1 species; India.

Pseudohowardina, Theobald. Head with squames and some sickles and darts in the middle line. Scutellum with sickles only. Male palpi long. 2 species; North America and Ceylon.

Culicimyia, Theobald. As *Pseudohowardina* but with a broader sagittal band of sickles and darts on the head. 12 species; Oriental and Ethiopian.

Neomacleaya, Theobald. As *Pseudohowardina*, but no darts on the head and only a double row of sickles. 1 species; Oriental Region.

Danielsia, Theobald. As *Pseudohowardina*, but the squames of the head are smaller and the sickles are limited to the nape. 5 species; Malay Peninsula, West Africa, Brazil.

Hispidimyia, Theobald. As *Pseudohowardina*, but the sickles are minute and are limited to the nape, the female palpi are one-fourth the length of the proboscis, and the long male palpi are clubbed. 1 species; Sudan.

Lepidotomyia, Theobald. As *Pseudohowardina*, but the palpi of the female are longer, and the proboscis is not more than half the length of the body. 1 species; India.

Gnophodæomyia, Theobald. As *Danielsia*, but the squames of the head are rounded, not truncated, and the scales in the distal part of the wing are dense and large. 1 species; Dutch Guiana.

Boycia, Newstead. As *Pseudohowardina*, but in the female the sickles are in two sagittal lines only and are almost entirely hidden by the darts, and the male palpi are clubbed. 1 species; Africa.

Bathosomyia, Theobald. As *Pseudohowardina*, but the squames of the head are looser, the sickles are confined to the nape, and no darts are present; and the sickles of the scutellum are coarser. 1 species; Africa.

Banksinella, Theobald. Head covered with squames and a broad sagittal band of sickles and darts. Scutellum with sickles. Male palpi long. 5 species; Africa and Oriental Region.

4. Uranotænia Series.

Uranotænia, Arribalzaga. Head and scutellum covered with imbricating squames; there may be some darts on the head and some sickles on the scutellum. Usually there are some elliptical squames on the scutum. Proboscis swollen at tip. Palpi short in both sexes. Some of the wing-scales may be broadly triangular or even heart-shaped. Fork-cells (particularly the 2nd marginal) very small. Small or minute mosquitoes, often with beautiful blue markings, found in tropical latitudes all round the globe; many species.

Anisocheliomyia, Theobald. Differs from *Uranotænia* in the setting of the squames of the head, and in the claws of the male, one of which in every foot is leaf-like. 5 species; South America, India, Australia.

Pseuduranotænia, Theobald. As *Uranotænia*, but the fork-cells are not quite so small. 3 species; South America and Philippine Islands.

5. Psorophora Series.

Psorophora, Robineau-Desvoidy. Head with some darts, but chiefly covered, like the scutum and scutellum, with broad elliptical squames that do not much overlap. Legs shaggy with outstanding scales. Palpi long in the male, short in the female. Large black mosquitoes with a metallic sheen, found only in America (including the West Indies). The larvæ are said to be extremely rapacious.

Ianthinosoma, Arribalzaga. Head with some darts but chiefly covered with elliptical squames which are closer set than and do not lie so flat as those of *Psorophora*. Scutum with elliptical squames and hairs. Scutellum with elliptical squames. Legs—more particularly the hind pair—somewhat thickened and roughened with outstanding scales. Palpi long in the male, short in the female. Mosquitoes of moderate size with metallic sheen (bronze or purplish), found only in America and the West Indies.

Ædinus, Lutz. Head with darts and elliptical squames. Scutellum with elliptical squames. Middle legs with some outstanding scales. 1 species; Brazil.

Gilesia, Theobald. Head, scutum, and scutellum covered chiefly with flat-lying elliptical squames which do not overlap. Wing-scales broadish. Palpi of the female about one-fourth the length of the proboscis. 1 species; Australia.

Maillotia, Sergent. Head with some darts but the predominant scales of the head, scutum, and scutellum are short, broad, curved scales which are much like the elliptical squames of Janthinosoma. Wing-scales narrow. 1 species; Algeria.

6. Mucidus Series.

Mansonia, Blanchard (=*Pneumaculex*, Dyar). Head shaggy with darts, broadish sickles, and—at the sides—loose

squames. Scutellum covered with sickles. Palpi of male long, of female about one-fourth, sometimes one-third the length of the proboscis. Wings with broad "butterfly" squames (*i.e.*, scales shaped like the front wing of a butterfly), sometimes combined with broad spatulate scales; the wings finely speckled, or mottled. The species, which seem to frequent big rivers, are found everywhere in tropical latitudes.

Mansonioides, Theobald. As *Mansonia*, but the middle lobe of the scutellum carries squames. 2 species; Oriental.

Mucidus, Theobald. Head shaggy with loose-set squames, darts, sickles, and huge, white, upstanding sickles with long, slender, sinuous stalks; these last also occur in some profusion on the scutum and scutellum. Palpi of male long, those of female from half to three-fourths the length of the proboscis. Wings speckled, wing-fringe spotted; the scales being broadly piriform or obovate squames. Abdomen and legs shaggy with outstanding spatulate and racquet-shaped scales. 7 species; Oriental Region, Australia, Tropical Africa.

Lepidoplatys, Coquillett. Head ragged with broad darts and broad sickles, and with loose squames at the sides. Scutellum with sickles, some of which are broad. Palpi of the male long; of the female, about one-third the length of the proboscis. Wings mottled; the scales are broad triangular squames, something like those of *Mansonia*. 1 species; North America.

Orthopodomyia, Theobald. Head thickly covered with broad darts and broadish sickles. Scutellum with sickles. Palpi of male from two-thirds to three-fourths, those of the female from half to two-thirds, the length of the proboscis. Wings with elliptical or spatulate scales; the costa and the field of the wing are spotted much like those of *Nyssorhynchus*. 3 species; Oriental.

Etorilepidomyia, Theobald. Head shaggy with upstanding squames, broad darts, and sickles. Scutellum with sickles. Palpi of female very short. Wings speckled; the scales are broad "butterfly" squames much like those of *Mansonia*, some of them are heart-shaped. 2 species; Africa and Philippines.

Newsteadina, Theobald. Head thickly covered with broadish sickles and broad darts, and with squames at the sides. Scutellum with squames and hair-like scales. Male palpi as long as the proboscis, female palpi more than half that length. Wings (and the costa and wing-fringe) spotted; the scales are broad *Mansonia*-like squames. 1 species; Mauritius.

Finlaya, Theobald. Head rough, with overlapping but loose-set squames, darts, and a few sickles. Scutellum with sickles and fan-shaped squames. Some large sickles scattered on the scutum. Male palpi shorter than the proboscis, female palpi short. Wings (and the costa and wing-fringe) spotted, or not; the scales are broad piriform squames. There may be ventral tufts of scales on some of the abdominal segments. 5 species; Malay Peninsula and Islands, New Guinea, Australia.

Ædimyia, Theobald. Head shaggy with loose-set fan-shaped squames and broad darts. Scutellum with squames. Scutum with elliptical squames. Palpi short in both sexes. Wings profusely speckled and spotted, and densely clothed with broad "butterfly" squames. 2 species; one of them is found all round the globe in tropical latitudes, the other, which is peculiar in having the legs plain brown, is found in French Guiana.

7. Forms Annectant between Culex, Stegomyia, and Ædes.

Myxosquamus, Theobald. A few sickles in the middle of the nape and round the eyes. Sickles of scutellum very broad, some of them almost squame-like. 1 species; West Africa.

Carrollia, Theobald. A few sickles in the middle of the nape. A few squames among the sickles of the scutellum. 1 species; South America.

Eumelanomyia, Theobald. A patch of sickles in the middle of the nape. Scutellum with sickles only. *Male palpi shorter than the proboscis.* 1 species; West Africa.

Acartomyia, Theobald. Some sickles scattered among the loose squames of the head, and a few squames among the sickles of the scutellum. Wings mottled with brown and grey scales. 1 species; Malta.

Bancroftia, Theobald. Some sickles in the middle of the nape; bristle-like darts very numerous; scutellum with some fan-shaped squames

among the sickles. Female palpi nearly one-third the length of the proboscis. 1 species; Brazil.

Catageomyia, Theobald. Some sickles on the nape; scutellum with some squames as well as sickles. 1 species; Africa.

Boycia, Newstead. A sagittal band or median patch of sickles somewhat obscured by darts. Squames of the head rather loose-set. Scutellum with sickles only. Proboscis swollen at tip. 1 species; Tropical Africa.

Genera and Species of Culicales *of Special Importance.*

CULEX, Linn. (Lat. *Culex*=gnat).

Head covered with "narrow curved" and "upright forked" scales on its dorsal surface, and with flat, imbricating scales on its sides. Scutellum covered with "narrow curved" scales. Palpi long in the male, short in the female. Wings with long slender "lateral" scales on the veins.

The species, which are numerous, are found in every part of the world; many of them are domestic, and breed in water-butts, drains, and temporary collections of house and rain water.

Culex mimeticus, Noe, which has been found in Southern Europe, Cyprus, India, Ceylon, the Malay States, and China, has the costa marked with three yellow spots like certain species of Anopheles.

Culex fatigans, Wiedemann, is one of the chief transmitters of the larva of *Filaria bancrofti*, and has been said also to carry the micrococcus of dengue.

Culex fatigans, Wiedemann,

is extremely like the common gnat (*Culex pipiens*, L.) of northern latitudes. It has been found in almost all the populous parts of the world between 40° N. and 40° S., and is one of the commonest house-haunting mosquitoes of the tropics. It is a brown mosquito with a broad white or pale yellow cross-band on every abdominal segment: the ventral surface of the abdomen, and the coxæ and the basal parts of the femora are pale, and except for a small pale spot ("knee-spot") at the tip of the femora (and sometimes also at the tip of the tibiæ), the legs are plain brown in the rest of their extent.

The larva, which may be found in any sort of water in and near human habitations, even in sewage, has a long slender breathing-tube, which is about two and a half times the length and twice the breadth of the slender, pointed tracheal gills. The shaft of the antenna is broader in its proximal two-thirds than in its distal third; the broader proximal portion is sparsely covered with microscopic spinules and carries distally a fan-like tuft of about twenty long branching hairs; the slenderer distal portion has numerous terminal hairs; the terminal segment of the antenna is minute and truncated. On either side of the 8th abdominal segment are three rather irregular rows of scales, which are rather numerous and stand in échélon.

Apart from its practical importance, *Culex fatigans* has a peculiar interest as being the living document of two discoveries of the first magnitude in the history of medicine, namely, Sir Patrick Manson's discovery (*Journal of the Linnean Society*, "Zoology," 1879) of the part played by mosquitoes in the life-cycle of certain filarial blood-parasites, and Sir Ronald Ross's discovery (*Indian Medical Gazette*, 1898 and 1899) of the necessary connection between mosquitoes and certain Protozoon blood-parasites. The first discovery laid open a new world to Pathology; the second, which is the outcome of the first, will affect the destiny of the human race.

STEGOMYIA, Theobald (Gr. στέγος = a house; μυῖα = a fly).

Head and scutellum covered with overlapping squames which on the scutellum are usually snow-white; usually some darts on the posterior part of the head. Palpi long in the male, very short in the female. Clypeus scaly. Smallish, black mosquitoes with bright (usually snow-white) markings on head and thorax, and generally with bright white cross-bands on abdomen and legs; common in tropical and sub-tropical latitudes all round the globe. Some of the best known species are thoroughly domestic in habits, living in human habitations, biting freely by day as well as at night, and laying their eggs in anything that happens to contain water. The eggs, so far as they are known, are dark—almost

black—and are not stacked in rafts. The larvæ, so far as they are known, are also much pigmented, have a short breathing-tube, and very large tracheal gills, and can live in water however foul, scanty, and precarious.

The notorious species in this genus is *Stegomyia fasciata*, Fabr., which, besides being the intermediate host of Filaria, was by Finlay discovered to be the nurse of the still mysterious (probably Protozoon) causative of yellow fever. Recently, moreover, Wenyon has discovered that in Baghdad *Stegomyia fasciata* is probably the intermediate host of the Protozoon parasite of the Baghdad sore.

Other species causally connected with disease are *Stegomyia pseudoscutellaris*, which Bahr has found to be an intermediate host of *Filaria bancrofti* in Fiji.

Stegomyia fasciata, Fabr. (Fig. 20).

Adult female.—Head black, with white markings disposed somewhat in the shape of a crown; palpi short, black tipped

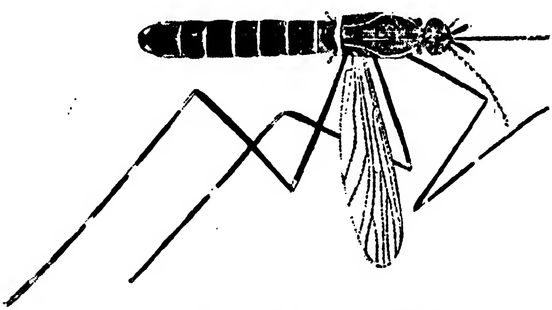

FIG. 20.—*Stegomyia fasciata*, female.

with white, or entirely white. Scutum brown, with a large lyre-shaped device, the broad limbs of the lyre snow-white, the two strings yellowish-white. Scutellum white. Abdomen blackish-brown, with white bands across the dorsum and white patches on the sides of the segments. Femora with white tip, most distinct in the hind legs; tibiæ black, tarsus of front and middle legs with two white bands, tarsus of hind legs with five white bands, the last of which includes the whole of the terminal segment.

Adult male.—Like the female, but the palpi are about the same length as the proboscis and have four, or three, white cross-bands.

Geographical Distribution.—*Stegomyia fasciata* seems to have been reported from nearly every well-inhabited part of the world between 40° N. and 40° S. It is found in places near the sea-level, and has been taken at an elevation of nearly 3000 feet.

Habits.—It is everywhere a house-haunting mosquito. According to Boyce, it is "probably the most common mosquito found on ships," though this is not my own experience. Like several other species of *Stegomyia*, it bites in the daytime as well as at night. Boyce states that he has never found it breeding more than 50 to 100 yards distant from human habitations, and that it breeds in anything and everything that will hold water, even in the heel of a broken bottle or in an old sardine-tin, or in a hole in a rotten tree; but that it prefers wooden receptacles, particularly water-barrels.

Eggs.—These are not compacted in a "raft," though they have some tendency to stick loosely together, and are almost black. It is important to remember that the eggs are remarkably resistant. Theobald bred out larvæ, in England, from eggs sent from Cuba in a dry test-tube, two months before, and other observers state that the eggs, if kept dry, remain fertile for terms of five to six and a half months. It is also important to remember that the infection of yellow fever can be transmitted through the egg to a second generation of mosquitoes.

Larva.—The larva is represented in the usual conventional position in Fig. 12, the last 2 segments of the body being shown in profile, the rest of the body in a dorsal view. It is dark coloured, and has a rather stumpy breathing-tube and very large tracheal gills. The shaft of the antenna is smooth except for a single hair near the middle and for three or four tiny hairs at the tip, and the terminal joint is minute and truncated. On either side of the 8th abdominal segment (Fig. 21) is a single row of eight or nine scales and a wisp of three small hairs, each scale having somewhat the shape of an arrow-head inverted. The larva is said (probably by

reason of its large tracheal gills) to be able to remain submerged for a remarkably long time.

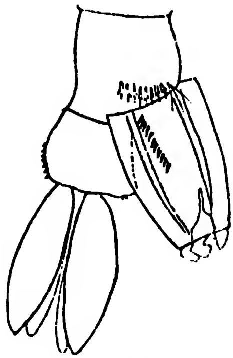

FIG. 21.—*Stegomyia fasciata*; end of tail of larva.

Stegomyia scutellaris, Walker.

This species requires to be mentioned, as, although it is not known to have any pathogenic business with man, it is very common in many tropical towns and in many particulars resembles *S. fasciata*.

Stegomyia scutellaris is a common house-haunting mosquito in all parts of the Oriental Region, also extending northwards to Japan, eastwards to New Guinea, and south-westwards to Mauritius and the Seychelles. Like *S. fasciata*, it is active in the daytime and breeds in house-water. It differs from *S. fasciata* in the colour-marking of the scutum, which consists of a single median longitudinal white stripe.

The *larva* is very much like that of *S. fasciata*; but the scales of the 8th abdominal segment are seven or eight in number and are long and somewhat bayonet-shaped.

Stegomyia pseudoscutellaris, Theobald.

This species seems to be very common in Fiji, and is said to haunt houses and to be active in the daytime. It has the median white stripe on the scutum, like *S. scutellaris*, but is distinguished from that species (1) by the presence on the pleural aspect of the thorax of three parallel white bands, the uppermost of which forms a white lateral border to the scutum on either side; and (2) by the white bands on the

abdomen being confined to the sides of the segments. According to Bahr, who has made a special study of the connection between insects and disease in Fiji, it transmits both *Filaria nocturna* and the Fiji filaria.

MANSONIA, Blanchard.

Head shaggy with curved scales (many of which are broadish) and upright forked scales dorsally, and somewhat outstanding flat scales laterally. Scutellum with broadish curved scales. The wing-scales are all broad plates of a roughly triangular shape something like the front wing of a butterfly; some of them may be merely spatulate; as the scales are generally of at least two colours—brown and whitish-yellow—the wings have a speckled or mottled appearance. The legs also are, usually, mottled and banded. The species are found all round the globe within the tropical zone, but not very far outside it; they particularly haunt the courses of big tropical rivers, but some may go into houses. Two of them are known to nurse the larvæ of *Filaria bancrofti*, namely, *M. uniformis* and *M. titillans.*

Mansonia uniformis, Theobald,

has a wide distribution, from West Africa eastwards through Madagascar, the Oriental Region, and New Guinea, to Australia. The scutum is brown, without any spots; the femora are mottled but not distinctly banded; the tibiæ are banded in alternate dark and white bars.

Mansonia titillans, Walker,

is a common South American species. The scutum is brown, without any spots; the proboscis has a fairly distinct or very indistinct yellow band; the femora and tibiæ are not banded, but some of the tarsal segments of the front and middle legs and all the tarsal segments of the hind legs have a broad yellowish-white bar at base. *Mansonia pseudo-titillans*, Theobald, is a synonym of this species.

Section III.—*Megalorrhini* (= *Megarhininæ*, Theobald) (Gr. μεγαλόρρινος = with large beak).

The species included in this small section are very large-sized, jungle mosquitoes having the proboscis strongly bent downwards and backwards. The body is covered entirely with flat scales—broad imbricating squames on the head, scutellum, and abdomen, narrower elliptical squames on the scutum—which are strongly iridescent. The wings are never spotted. Both the "fork-cells" (2nd marginal and 2nd posterior) are remarkably small. The metanotum is bare. The palpi of the male are about the same length as the proboscis, those of the female are sometimes as long as, sometimes considerably shorter than the proboscis. As a rule the sides of the terminal segments of the abdomen are thickly fringed with long, narrow, often bright-coloured bristles. Larva with a breathing-tube.

The larvæ (Fig. 15) are carnivorous and are undoubtedly predatory upon the larvæ of such *Culicidæ* as breed in ponds, or in any small casual collection of water, in or near jungle. They can be recognised, apart from size, by the stiff shortly-pinnate bristles or spines that represent some of the lateral thoracic and abdominal hairs of other Culicine larvæ; and by their stiff rake-like mouth-brushes. It must be remembered, however, that spines of much the same kind occur in certain other Culicine larvæ that live in chance collections of water in jungle, and that similar mouth-rakes are found in certain other *predatory* Culicine larvæ.

Theobald recognises three genera in this homogeneous little section, namely, *Megarhinus*, Robineau-Desvoidy, in which the palpi are long in both sexes and end bluntly in the female; *Ankylorhynchus*, Lutz, in which the palpi are long in both sexes and are pointed in the female; and *Toxorhynchites*, Theobald, in which the palpi of the female are less than half the length of the proboscis. The species of *Megarhinus* occur only in the Neotropical Region and its confines, those of *Ankylorhynchus* (three in number) are exclusively Neotropical; while *Toxorhynchites* though chiefly Oriental is also represented in the Australian and Ethiopian regions.

So far as is known none of the species is implicated in the conveyance of any disease of man, and of some species it is certainly known that they are reluctant to attack man at all.

Section IV.—*Metanototricha*, Theobald.

The species included in this small section are recognised by their metanotum, on which there may be a few bristles, or a few scales, or both bristles and scales; most often the bristles alone are present in a not very conspicuous wisp at the apex of the metanotum. The head and scutellum, and usually the scutum also, are covered with flat scales (squames). The proportions of the palps are not constant; sometimes they are quite short in both sexes, sometimes they are short in the female only. The colouring is often iridescent or brightly metallic. The species are denizens of the jungle, and their headquarters is in the Neotropical Region, though they are represented in Tropical Africa, the Oriental Region, and New Guinea. Theobald makes three subfamilies of them; but it is really very doubtful whether they should be recognised as a distinct section of the subfamily *Culicinæ*.

CHAPTER VI

Blood-sucking Nematocera (*continued*): **Psychodidæ, Chironomidæ, Simuliidæ**

BESIDES Mosquitoes three other families of Nematocera, namely, the *Psychodidæ*, or Moth-like midges, the *Chironomidæ*, or Midges, and the *Simuliidæ*, have to be reckoned in the census of blood-sucking flies. In the blood-suckers of all these families the mouth-parts, like those of the female mosquito, include mandibles and maxillæ formed for cutting and sawing, and the epipharynx is a dagger. So far as the *Simuliidæ* and the few blood-sucking *Chironomidæ* are concerned the habit seems to be peculiar to the female.

Family PSYCHODIDÆ: Moth-like Midges. (Gr. ψυχή = moth or butterfly; εἶδος = form).

The species of this family are small, sometimes minute, midges having the body and wings thickly covered with hair, amid which patches of scales may be interspersed. Their resemblance to tiny moths is enhanced by the pose of the wings, which, when at rest, are commonly—but not in the blood-sucking *Phlebotomus*—sloped on either side of the body. The wings are peculiar in their oval or lanceolate form, and in their venation (Fig. 22). Owing to the facts that the veins usually branch nearer to the root than to the tip of the wing, that the cross-veins are inconspicuous and are also situated near the root of the wing, and that the 2nd longitudinal vein has three branches, the wings look as if they contained nine or ten nearly parallel longitudinal veins without cross-veins. The antennæ are long, and their segments, which are sixteen in number, usually are separated by deep constric-

tions and carry whorls of hairs. These peculiarities of the antennæ and wings are less manifest in *Phlebotomus* than in other *Psychodidæ*. Except in the blood-sucking *Phlebotomus* the proboscis is short and inconspicuous.

Psychodidæ are found in all parts of the world; they have a preference for damp shady places, outhouses, privies, etc., and they hop rather than fly when disturbed. The larvæ live in rotting vegetation, crumbling masonry, liquid filth, etc., and some are aquatic.

Several species of the family have been suspected of sucking blood, but this habit is known to prevail only in the species of the genus *Phlebotomus*, which are notorious as blood-sucking pests in many parts of the world. One species, *Phlebotomus papatasii*, has recently been proved to be the

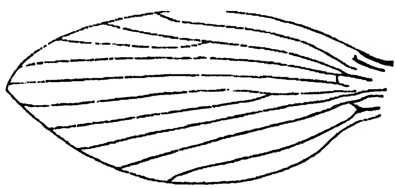

FIG. 22.—Wing of *Psychodid*.

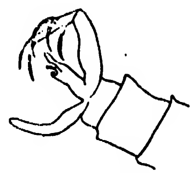

FIG. 23.—Male *Phlebotomus*.

infective agent of a specific three-day fever which is prevalent in certain parts of Southern Europe in the autumn, and other species have been suspected, without any proof, however, of nursing the protozoon parasite of Delhi boil.

The *Psychodidæ* are grouped in two subfamilies, namely, (1) *Psychodinæ*, in which the 2nd longitudinal vein makes its first branch in the root of the wing (Fig. 22), the female has a horny ovipositor, and the external genitalia of the male consist of two pairs of clasping-pieces; and (2) *Phlebotominæ*, in which the 2nd longitudinal vein branches well in the field of the wing, the female has not a horny ovipositor, and the genitalia of the male (Fig. 23) consist of three pairs of clasping-pieces in addition to the penis.

Subfamily *Phlebotominæ*.

The only genus that concerns us is *Phlebotomus* (Fig. 24), the species of which are small, yellowish, greyish, or brownish

midges, of a slenderer build than most *Psychodidæ*, and carrying their wings, in repose, uplifted. The joints of the antennæ are not remarkably constricted; the legs are extremely lanky; the proboscis is long, and the tips of the piercing parts may project beyond the labium; and the wings are rather narrow, with all three branches of the 2nd longitudinal vein readily seen.

It is commonly supposed that the female alone sucks blood; but in some species the male has mouth-parts quite like those of the female, and Neveu-Lemaire says of an

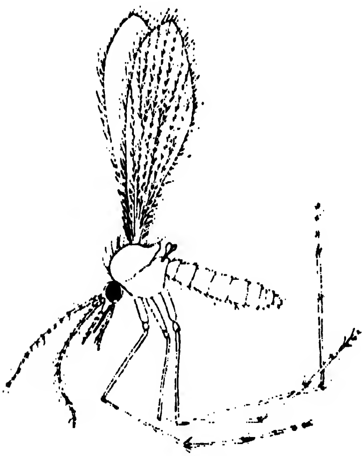

FIG. 24.—Female *Phlebotomus*.

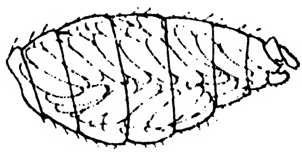

FIG. 25.—Abdomen of female *Phlebotomus*.

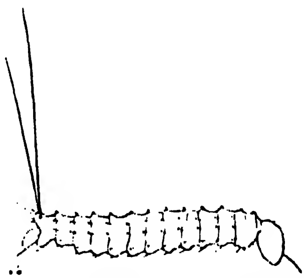

FIG. 26.—*Phlebotomus*, young Larva; after Newstead.

African species (*P. duboscqii*), "it seems that the males can bite as well as the females." The species of *Phlebotomus* are so small that they can creep through the meshes of an ordinary mosquito-net, and their bite causes great local irritation. As a rule these insects bite at night, and rest by day in dark corners of rooms, bathrooms, privies, cellars, etc.

According to Grassi the female of the common species of Southern Europe (*P. papatasii*) lays about forty eggs (*cf.* Fig. 25), the larva (Fig. 26) can be recognised by long bristles—two in the young, four in the full-grown larva—situated on a pair of tubercles on the last segment of the body, and the pupa by the shrivelled larval skin which adheres to the

posterior end of the body. According to Howlett the whole life-cycle of one of the Indian species, from the laying of the egg to the emergence of the adult from the pupal skin, may take about a month in the hot weather and two months or more in the cold weather. According to Grassi the larvæ and pupæ of *P. papatasii* are found in dirty cellars and dark damp places containing building-materials and rubbish; and Austen, summarising the recorded observations of the breeding-places of the species of *Phlebotomus*, sees good grounds for thinking that the chief situations are the walls and woodwork of permanent latrines, privies, and cesspools, above the level of the fluid contents. In Malta, Captain Marett found both larvæ and pupæ in crannies in stone walls and embankments and in crevices in caves—and *only* in these places.

The genus is represented in South Europe, Africa, South Asia, and North and Tropical America.

1. *European Species.*

Phlebotomus papatasii, Scopoli. Pale yellowish-grey; thorax with a dull red-brown median stripe, and a spot of the same colour on either side. Abdominal hairs more or less erect. Second segment of palpi a little longer than 3rd. Average length of hind leg 4 mm. Terminal segment of upper clasper of male slightly longer than the lower clasper.

Phlebotomus mascittii, Grassi. Differs from *P. papatasii* only in the form of the male claspers, the five spines of the terminal segment of the upper clasper being very long and falciform.

Phlebotomus perniciosus, Newstead. Thorax with or without dull red spots arranged in a triangle. Abdominal hairs more or less erect. Second and 3rd segments of palpi equal in length. Average length of hind leg 3 mm. Terminal segment of upper clasper of male hardly half the length of the lower clasper.

Phlebotomus minutus, Rondani. Length of female 2 mm., of male considerably less. Integument ochreous. Second segment of palpi half the length of the 3rd. Abdominal hairs recumbent. Terminal segment of upper clasper of male with only four spines.

Phlebotomus nigerrimus, Newstead. Length of female 2½ mm. Integument black. Second segment of palpi slightly longer than the 3rd. Abdominal hairs recumbent.

2. *African Species.*

Phlebotomus duboscqii, Neveu-Lemaire. About the same size as *P. minutus*. General colour pale yellow. Wing narrow, about three times as long as broad: 2nd marginal cell less than a third the length of the wing.

3. *Oriental Species.*

According to Annandale *P. papatasii*, Rondani, is found in Northern India.

P. argentipes, Annandale. Head and abdomen brown; dorsum of thorax dark brown or blackish; sides of thorax, coxæ, and trochanters yellowish; legs, antennæ, and palpi grey; the whole, especially the legs, with a silvery sheen. Wings grey with bluish iridescence and silvery sheen. Greatest breadth of wing about a third its length; greatest length of 2nd marginal cell ("first fork-cell") about a third the length of the wing. India.

P. major, Annandale. Uniform grey with strong silvery lights, disk of wings with a bluish iridescence. Greatest breadth of wing not quite a third its length; greatest length of 2nd marginal cell a little more than a third the length of the wing. India.

P. malabaricus, Annandale. Thorax, abdomen, and legs (except coxæ and trochanters) brown with a tinge of purple and with silvery lights; wings purplish, strongly iridescent. Greatest breadth of wing about a third its length; greatest length of 2nd marginal cell nearly half the length of the wing. South India.

P. babu, Annandale. Silvery grey. Greatest breadth of wing between one-fourth and one-fifth its length; greatest length of 2nd marginal cell less than one-fourth the length of the wing. India.

P. himalayensis, Annandale. Yellowish-grey with silvery lights. Greatest breadth of wing slightly over one-fourth its length; greatest length of 2nd marginal cell a little more

than a third the length of the wing. Himalayas, between 4000 and 7000 feet.

P. perturbans, Meijere. Head and thorax yellowish-brown, abdomen brown with darker glistening hairs; femora yellow with brown tip; tibiæ and tarsi brown with silver sheen. Greatest breadth of wing one-third its length; greatest length of 2nd marginal cell a little more than one-fourth the length of the wing. Batavia.

P. angustipennis, Meijere, from Netherlands India is thought by Annandale to be synonymous with *P. papatasii*, Rondani. The wings are long and narrow, and the 2nd marginal cell is barely a third the length of the wing.

4. *American Species.*

P. vexator, Coquillett. Yellow; mesonotum brown; legs appear brown in certain lights, but are covered with white tomentum; 2nd marginal cell slightly over twice the length of its petiole. North America.

P. cruciatus, Coquillett. Like *P. vexator*, except that the hairs are chiefly yellow, and the 2nd marginal cell is about thrice the length of its petiole. Guatemala.

Family CHIRONOMIDÆ: Midges *par excellence*
(Gr. χειρονόμος = one who gesticulates with the arms).

Chironomidæ are typical midges many of which greatly resemble mosquitoes; but they can be distinguished, apart from other characters, by the proboscis, the wings, and the pose: the proboscis is short—even in the females of the blood-sucking species, which do not resemble mosquitoes, it is not very long; the wings are not scaly, though they may be hairy, and the costal vein stops at the tip of the wing; and in repose the front legs are usually uplifted—whence the name *Chironomus*. The antennæ of the male are thickly plumose, those of the female may be either short or long; the thorax generally projects a good deal over the back of the head; the wings are either bare or hairy, the anterior veins are usually thicker and darker than those in the posterior part of the wing, the 2nd longitudinal vein is wanting—and often the posterior cross-vein also—and the

3rd, 4th, and 5th longitudinal veins may all be forked. The family is a very large one and is represented in all parts of the world and at all altitudes, the commoner species occurring in dancing swarms near water. The larvæ are mostly aquatic, but some live in the sap that flows from diseased trees, and in decomposing vegetation. Only the females of certain species of the subfamily *Ceratopogoninæ* suck blood.

The eggs of *Chironomus* are laid in strings or lumps of transparent jelly-like mucus, in stagnant water, and the aquatic larvæ—which, from the hæmoglobin contained (in solution) in the blood of many species, are often red, and hence are known as "blood-worms"— may come to the notice of the medical officer when they are found, as they often are, in the settling-tanks of waterworks, or in water stored for domestic use. The larva (Fig. 27), which resembles

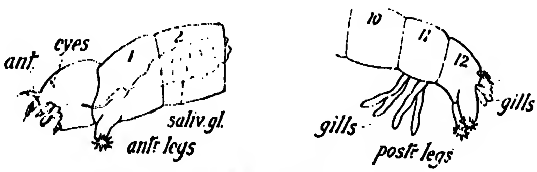

FIG. 27.—Head and after end of *Chironomus* Larva.

a small river-worm, may sometimes be seen writhing through the water, but it often lives in temporary tubes formed of mud and fine debris entangled in slime secreted by the large salivary glands (Fig. 27). It is composed of a head and twelve segments; on the head there are two pairs of small eye-spots, a pair of antennæ, and mouth-parts formed for biting; on the first and last segments of the body there are two short legs ending in a ring of hooklets; on the ventral surface of the penultimate segment there are four longish filaments, and at the end of the last segment there are four shorter filaments; these act as true gills, the tracheal air-system being not functionally developed. Different species of *Chironomus* larvæ have different habits; some common species are found in ditches, ponds, and water-butts; other species live at the bottom of deep lakes, or even at the bottom of the sea. The pupa of *Chironomus* has a general resemblance to that of *Culex*, but breathes by a pair of thick

tufts of (cephalothoracic) breathing-threads instead of breathing-trumpets. The aquatic larvæ of some *Chironomidæ* are rapacious.

The majority of the blood-sucking Chironomids belong to the Ceratopogonine genera *Culicoides*, Latreille (with which, according to Williston, *Œcacta*, Poey, is synonymous) and *Johannseniella*, Williston (= *Ceratolophus*, Kieffer). The species of *Culicoides* (Fig. 28) are found in all parts of the world; the females bite during the day and at evening, and in many parts of India—as well, according to Graham, as in

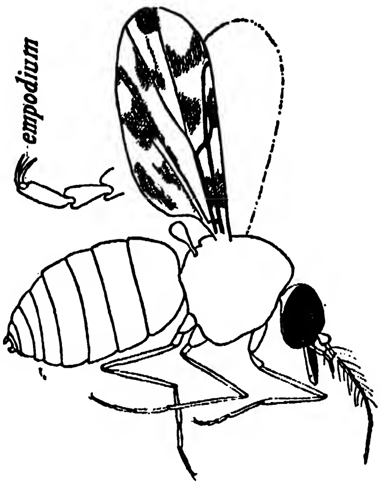

FIG. 28.—*Culicoides* sp.

West Africa—are, by Europeans, popularly (or, rather, unpopularly) known as "sand-flies"—a name which some entomologists apply to the species of *Phlebotomus*. They are minute midges, generally of a blackish colour (when not full of the red blood of a victim) and having broadish, usually blotched and minutely-hairy wings; the antennæ consist of 14 segments, the 4th and 5th longitudinal veins are forked and there are no posterior cross-veins, and the empodia are much shorter than the claws. The larvæ are slender and worm-like, and they live in the sap that exudes from injured trees. The species of *Culicoides* often attack in swarms; although they are so minute they can bite through a stocking, and their bite is particularly irritating, often

raising a large bump that itches for days; the bite is not known to carry any specific infection, but *Culicoides* is one of the insects that has been suspected of inoculating the micro-organism of Delhi boil.

Johannseniella is said to differ from *Culicoides* in having no empodia: the wings are usually bare.

Family SIMULIIDÆ (Lat. *Simulus* = snub-nosed).

The species of this family (Fig. 29) are small, thickset, unmidgelike flies, with short stout legs, large broad wings, a short and heavy, but formidable proboscis, and short stiff

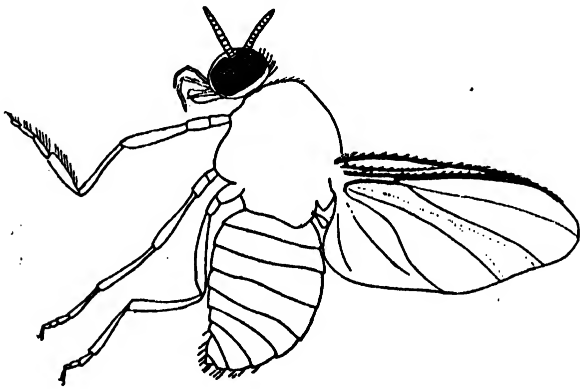

FIG. 29.—*Simulium nigrogilvum.*

antennæ composed of 10 segments not bearing whorls of hairs. They are very often all black, but may be reddish-brown, or may have the legs conspicuously banded, or the thorax beautifully striped; and one of the Oriental species is almost as vividly coloured as a wasp. The costal, sub-costal, and 1st and 3rd longitudinal veins (the 2nd longitudinal vein is absent) are stout and bristly, but the other longitudinal veins, which are forked, are faint to the verge of invisibility; the costal vein ends at the tip of the wing. The mouth-parts of the female are formed for stabbing and cutting (Fig. 30); in general they resemble those of the female gadfly but are, for their size, even more formidable; the epipharynx is armed at its tip with recurved hooklets, and the mandibles and maxillæ are shaped like lancets, the

mandibles being very sharply serrated for some distance along the inner edge, and the maxillæ along the outer edge. The maxillary palps, which are long and flexible, consist of 4 segments, and in the 2nd segment there is a sensory vesicle with a minute opening to the surface.

The species are extremely numerous, are represented under suitable conditions in all parts of the world, and are all included in the one genus *Simulium.* The females are insatiable blood-suckers, active by day. In some countries they appear, at certain seasons, in swarms, and attack cattle and other domestic animals with fatal effect. A Himalayan

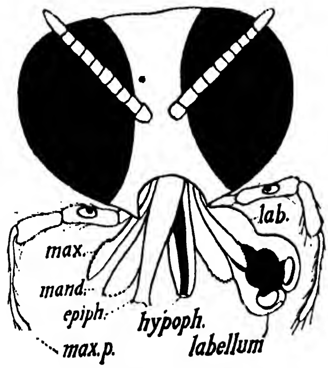

FIG. 30.—Head of *Simulium.*

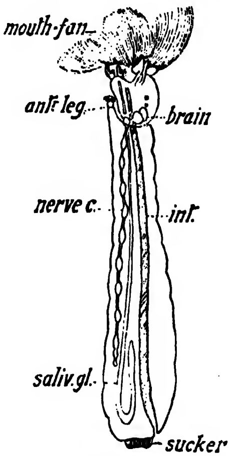

FIG. 31.—*Simulium* Larva.

species has been said to kill even human beings in the same way; but whether in these cases death is caused—as in the analagous cases of death from the attack of a swarm of bees—by a multitude of envenomed wounds, or is due to the inoculation of some pathogenic microbe is not known. It cannot be affirmed that *Simulium* is a "carrier," so far as man is concerned; but from certain coincidences in the geographical and physiographical distribution of *Simulium* on the one hand, and the endemic and seasonal prevalence of pellagra on the other, Dr Sambon assumes that there is some causal connection between the fly and the disease.

The eggs of *Simulium* are laid in gelatinous masses on

submerged stones and water-weeds, and the larvæ are aquatic. So far as is known the larvæ can live only in the well-aerated—though not necessarily clean—water of rapid streams. Larvæ of one of the common British species, removed from their natural habitat and kept with proper care in an aquarium, will live for a few days, but they eventually die with their gills extruded, which is fair evidence of asphyxia.

The larva (Fig. 31) is composed of 12 not very well-defined segments besides the head, and is shaped something like a slender flask, its after part being moderately inflated. The well-chitinised head, in addition to two pairs of eye-spots, a pair of antennæ, and mouth-parts formed for biting, carries a pair of large and particularly elegant mouth-fans, each of which is composed of a row of about fifty long and regular filaments articulated to a stout flexile stalk; these are used for sweeping food towards the mouth. On the ventral surface of the 1st segment of the fleshy body there is a stumpy leg (formed of a pair of fused appendages) crowned with hooklets, and at the end of the last segment there is an elegantly burred sucker (also formed of a pair of modified appendages); these are used for creeping, after the manner of a leech, but the front foot is also used for fashioning the silky secretion of the salivary glands, and for pushing food towards the mouth, and the sucker is a very necessary organ of attachment, one of the most characteristic attitudes of the larva being to sit upright on the end of its tail—to use the language of the poets of the daily press—with its mouth-fans standing out from its head like a pair of shaggy ears. The larva possesses a pair of extremely long tubular salivary glands (Fig. 31), which are used for spinning anchoring-threads and life-lines—an adaptation, like the sucker, for life in turbulent waters. Judging from the contents of the alimentary canal, which runs straight through the body (Fig. 31), the larvæ live on microscopic vegetation, but they can often be observed, as they sit together in crowds, pecking at passing larvæ of other kinds and sparring one with another. According to Miall the tracheal tubes are large and give off a network of fine branches to the skin; but in one very common British

species breathing seems to be carried on, very much as it is in certain dragon-fly larvæ, by delicate rectal gills (Fig. 32), which are alternately pushed out and retracted.

When the larva is about to pupate, it spins, from its salivary glands, a silky cocoon, which may be found attached to water-weeds, etc. The cocoon is often shaped something like a slipper (Fig. 33), or it may be merely a widely open cone. The pupa occupies it loosely, holding on by some belts of small spinules on the posterior abdominal segments, and from the open end of the cocoon the pair of thoracic gill-tufts, by which the pupa breathes, floats out. Towards the end of the pupal stage gas accumulates beneath the skin

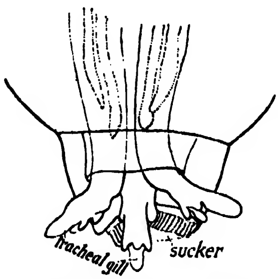

FIG. 32.—Extruded Rectal Gills of *Simulium* Larva.

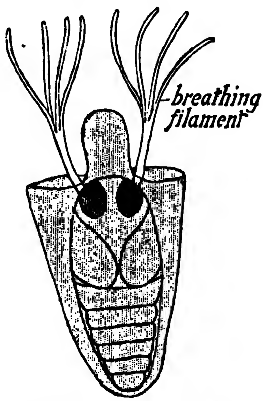

FIG. 33.—Pupa and Cocoon of *Simulium*.

of the pupa, so that when the skin splits to give exit to the fly, the gas escapes in a bubble which carries the fly safely to the surface of the water. The larval stage is said to occupy about a month in the summer months, and the pupal stage about a week.

Since *Simulium* is in many places such a formidable pest, the question of destruction of larvæ has to be considered. Among natural enemies trout and fish of similar habitat come first. Miall mentions caddis-worms, and my pupil, Miss Sophia Summers, confirms this from observation in the laboratory. Since the larvæ require running water, it has been recommended that parts of streams where they are numerous should be dammed, to their ultimate destruction.

The water thus turned stagnant might, to complete the business, be blasted with dynamite, or (with infinite caution) poisoned. In the United States Phinotas oil—a heavy oil that sinks—has been applied even to running streams with much success. The exactly opposite course of deepening and clearing the bed of the stream, so as to accelerate the current and sweep away the larvæ, has also been recommended. To repel the adult flies (females) some distasteful application may be used; for animals, an ointment of tar or petroleum; for human beings, a lotion of some powerful essential oil made up with a solution of quinine or an infusion of quassia.

CHAPTER VII

Nematocera (*continued*): Harmless Nematocera

THE eight remaining families of Nematocera are not of any particular interest from the medical standpoint, but the medical officer should be able severally to distinguish them as there are many species among them that might be confused with mosquitoes. They are here styled harmless, since they do not suck blood, but many of the species are hurtful to agriculture.

Family TIPULIDÆ; Crane-flies or Daddy-longlegs (Lat. *tippula* =a light, long-legged insect).

This family, which is represented in all parts of the world, includes a great many species, some of them being the largest of all Nematocera and the longest of all Diptera. In the great majority there is an open V-shaped suture across the scutum in front of the wings, and a discal cell in the wing. The legs are remarkably long and delicate, the genitalia are prominent, and the proboscis in some species is elongated. Some of the smaller species dance in the air in swarms like gnats. The larva has a distinct head with antennæ that usually are minute, and well-formed mandibles and maxillæ; on the ventral surface of some of the segments of the body there are small bristly tubercles for locomotion. The larvæ of most species live in the earth or in rotting wood, but some live on the leaves of plants, and, being coloured green, resemble caterpillars, and some are aquatic and have a long contractile breathing-tube at the end of the body. The pupæ have slender thoracic breathing-tubes one of which in some aquatic forms is of prodigious length. A few species of *Tipulidæ* are wingless.

Family DIXIDÆ (Gr. δίξος=of doubtful position).

This family, which is supposed to connect the *Tipulidæ* with the *Culicidæ*, contains one genus *Dixa*, the species of which are very widely distributed. The adult is very much like a mosquito, but can be distinguished by the short proboscis, the absence of a "wing-fringe" of scales, and the curious course of the 2nd longitudinal vein, which arches forward, at the point of origin of the 3rd longitudinal, in such a way that its proximal part appears to belong to the latter. The larva (Fig. 34)

has a certain amount of resemblance to a Culicid larva, except that the thorax is not differentiated from the abdomen: it consists of a head with antennæ, mandibles, and maxillæ, and with mouth-brushes much like those of a *Culex* larva, and of 12 body-segments; on the dorsal surface of the penultimate segment of the body there is a pair of breathing-openings like those of Anopheles situated in a depression which is

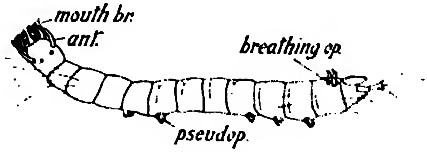

FIG. 34.—Larva of *Dixa*.

protected by stiff setose flaps; on the ventral surface of some of the body-segments there are pairs of spinose pseudopods. The larva creeps about on aquatic vegetation close to the water's edge, and has the habit of carrying its body strongly bent; when submerged it swims by vigorous contortions. The pupa much resembles that of *Culicidæ*. I have received the larvæ of *Dixa* as "worms" passed in the urine of a patient—*caveat medicator.*

Family RHYPHIDÆ.

This is a very small family but is widely distributed. One of the species, *Rhyphus fenestralis* (Fig. 35), is commonly found on windows and mistaken for a mosquito, or even, by reason of its spotted wings, for

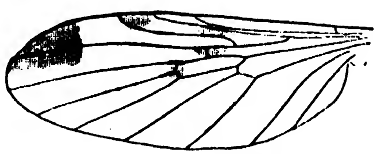

FIG. 35.—Wing of *Rhyphus*.

an *Anopheles*. The antennæ are of fair length, are composed of 16 segments, and do not carry whorls of hairs. In the wings there is a discal cell, and the 2nd longitudinal vein is not forked. In the legs the empodium is pulvillus-like, and the true pulvilli are vestigial. The larva is slender and worm-like.

Family CECIDOMYIDÆ: Gall-gnats (Gr. κηκίς = a gall; μυῖα = fly).

The species of this large family (Fig. 36) are small (often minute) delicate midges, with long (often moniliform and plumose) antennæ, long slender legs, and broad, filmy, often hairy wings. The proboscis is generally short. The wings commonly have only three longitudinal veins, two of which are very faint; but sometimes there are four or five; the costal vein is continued all round the edge of the wing. The tibiæ do

not end in long spines. The larva is often red or yellow, is stumpy, is pointed at both ends, and consists of a head and the very unusual number of 13 trunk-segments; it breathes by numerous spiracles situated on the sides of some of the segments: in many species there projects, on the ventral surface, between the 1st and 2nd body-segments a curious, often pointed or serrated process, known as the "breast-bone." The larvæ are sometimes found in decaying wood or fungi, but generally are parasitic in living plants, forming excrescences or galls. The "Hessian-fly," so destructive to crops in some parts of the world, is the larva of a *Cecidomyia*. The larvæ of a few species bud-off internally, during the winter, another generation of larvæ; these consume the parent-larva, escape from its empty skin, and may themselves repeat and suffer the same process; and this may go on through several generations, until the summer, when the final brood completes its normal development.

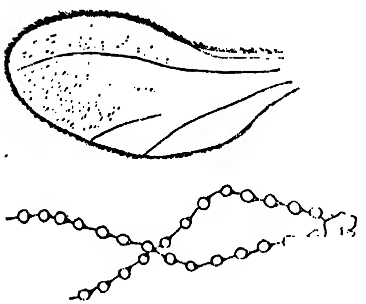

FIG. 36.—Gall-gnat: Wing and Antennæ.

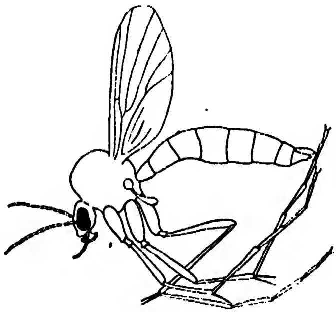

FIG. 37.—Fungus-gnat.

Family MYCETOPHILIDÆ: Fungus-gnats (Gr. μύκης = fungus; φιλεῖν = to love).

In the species of this large family (Fig. 37) the coxæ of the legs are usually much elongated and the tibiæ end in spines; the antennæ are long and slender and have not whorls of hairs; ocelli, which may be three or only two in number, are generally present; the costal vein stops at the tip of the wing. The larva is worm-like, but has a distinct head with well-formed mouth-parts; it usually has, like the Cecidomyid larva, numerous lateral spiracles on the body. The larvæ are gregarious, and often have a preference for fungi, whence the name fungus-gnats; some spin a silky web for common protection, some are luminous, and some exude a slimy mucus. Those of certain species of *Sciara* found on the continent of Europe and in North America, are said to stick together in long coherent strings which progress bodily like snakes—a remarkable instance of puzzling corporate action. The larvæ of a minute wingless Mycetophilid are said to damage stored potatoes. A species of *Sciara* is known in America as the Yellow-fever fly, because in certain places in the southern States its appearance in unusual numbers has several times

coincided with an epidemic of that disease. In the subfamily (*Sciarinæ*) to which *Sciara* belongs the coxæ are only moderately elongated and the form of the body is often not characteristically gnat-like.

Family Bibionidæ (Lat. *Bibio*=a must insect).

The species of this family are found in most parts of the world; some of them, in northern latitudes, appear in swarms in the spring. In colour they are generally black or red, or sometimes yellow; and in form they are often stout and unmidgelike. The antennæ, which are shorter than the thorax and do not bear whorls of hairs, are composed of numerous (8 to 16) short, broad, compact segments. The tibiæ of the front legs end in a hook or a circlet of small spines. The wings are large and the costa does not extend beyond their tip. Ocelli are present and are very distinct, and in the male the compound eyes are generally large and are sometimes hairy. The larva has a well-formed head with biting mouth-parts; there are belts of bristles or spines round the trunk-segments, and numerous lateral spiracles. The larvæ of some species feed on the roots of plants and may do injury to grass and crops. A British species of this family, *Dilophus febrilis*, is known as the fever-fly.

Family Blepharoceridæ (Gr. βλεφαρίς=eyelash; κέρας=antenna).

This is a small group of mosquito-like flies found mostly in America in the neighbourhood of streams, but also occurring in Europe and Asia. They are distinguished from all other flies by the wings, which in addition to the ordinary venation have a fine net-work of creases ("secondary venation") resulting from the folding of the wings in the pupal stage. According to Williston the proboscis is elongate, as are the other mouth-parts, and in the female long slender serrated mandibles are present, the female being predaceous on other flies. The antennæ are slender and are without whorls of hairs. On the scutum, in front of the wings, there is an interrupted transverse suture. The larvæ, which live in rapid streams, are said to resemble a small Crustacean rather than the larva of an insect; they are composed of a small number of segments separated by deep constrictions, and on the ventral surface there is a row of suckers some of which bear tufts of tracheal gills. The pupæ also are said to be peculiar, having a soft flat ventral surface with suckers for clinging to stones in the bed of the streams in which they live, and a hard convex dorsal surface from which, anteriorly, a pair of tracheal breathing-organs projects.

Family Orphnephilidæ (Gr. ὀρφνη=gloom; φιλεῖν=to love).

This family includes a single genus *Orphnephila*, the species of which, though few in number, are widely distributed. They are small brown or yellowish flies with antennæ that appear to consist of 2 segments and a terminal arista; but both the 2nd segment and the arista are complex and are together composed of 10 or 11 subsegments. In both sexes the eyes are large and meet across the head.

CHAPTER VIII

Order Diptera (*continued*): The Brachycera

IN the Brachycerous Flies the antennæ usually consist of 3 dissimilar segments of which the third is often elongate, is sometimes composed of several indistinctly-separated and not-independently-movable subsegments, and sometimes carries a terminal or subterminal, rarely dorsal, arista, or a terminal style. Sometimes the antennæ consist of 4 or 5 segments, and in certain species of one family (*Leptidæ*) the segments are very numerous. The maxillary palps are usually composed of 1 or 2 segments and are stiffly extended. The venation of the wings is often complex; the 2nd longitudinal vein is not forked, but the 3rd and 4th often are.

This section embraces fifteen families of flies, in one of which—the large family *Tabanidæ*, or Gadflies—the females habitually suck blood, while in another—the *Leptidæ*—there are a few blood-sucking species, and in a third—the *Asilidæ*, or Robber-flies—certain species have occasionally been reported as attacking man.

On the other hand the species of several large families are habitually predaceous on other insects, some of them being largely or exclusively predaceous on other flies, and so are to be regarded as probable or possible benefactors of man.

In the following synopsis the families which affect man in any way, for good or ill, are printed in capitals and will be considered in the sequel:—

Synopsis of the Families of Brachycera.

I. The 3rd antennal segment is composed of a series of indistinctly-separated subsegments; the empodia are pulvilliform; the 3rd and 4th longitudinal veins are forked:—

(*a*) The costal vein extends all round the wing; squamæ large; the 3rd antennal segment never has a style or arista TABANIDÆ.

(*b*) The costal vein extends all round the wing; squamæ small; the 3rd antennal segment may have a style or arista or not, or the antenna may consist of a large number of segments LEPTIDÆ.
(*c*) The costal vein does not reach beyond the tip of the wing *Stratiomyidæ* and *Acanthomeridæ*.

II. The 3rd antennal segment is simple, not compound, and may have a style or arista, or not; the empodia are pulvilliform:—
(*a*) Head small, formed almost entirely by the eyes; thorax large and humped; squamæ peculiarly large *Acroceridæ*.
(*b*) Squamæ small or moderate; venation of wings peculiarly intricate *Nemestrinidæ*.
(*c*) Squamæ small; wing-venation more or less like Tabanus (Fig. 6) LEPTIDÆ.

III. The 3rd antennal segment is simple, and may have a style or arista, or not; the empodia, when present, are bristle-like; the 3rd longitudinal vein is forked (and often the 4th also):—
(*a*) Crown of head concave between the eyes:—
i. The proboscis is a rigid chitinous dagger; bristly, hairy flies ASILIDÆ.
ii. The proboscis has fleshy labella; antennæ of 4 segments *Midaidæ*.
(*b*) Crown of head not excavated between the eyes:—
i. Wing with five posterior cells, the 3rd and 4th longitudinal veins curve forwards *Apioceridæ*.
ii. Wing with five posterior cells, the 4th longitudinal vein does not curve forwards; predaceous flies THEREVIDÆ.
iii. Wing with three or four (rarely five) posterior cells and often with dark markings; anal cell large; usually hairy bee-like flies, often with a long slender proboscis for sucking the nectar from flowers *Bombyliidæ*.
iv. Wing with three or four posterior cells, anal cell often small; femora and tibiæ often with combs of spinules; smallish dull-coloured predaceous flies usually with a stiff proboscis for impaling prey EMPIDIDÆ.
v. Wings with three posterior cells; proboscis not projecting; smallish flies usually found on windows *Scenopinidæ*;

IV. The 3rd antennal segment is simple, and may have an arista or not; the empodia when present are bristle-like; 3rd longitudinal vein not forked:—
(*a*) Wings shaped like a lance-head, the venation somewhat as in Psychodidæ *Lonchopteridæ*.
(*b*) Second basal cell confluent with discal cell; anal cell, if present, small; usually brilliant-coloured flies with metallic sheen DOLICHOPODIDÆ.
(*c*) Second basal and discal cells either confluent or distinct; anal cell, if present, small; not brilliant-coloured flies EMPIDIDÆ.

Family TABANIDÆ; Gadflies, Cleggs, Seroot-flies. (Lat. *Tabanus* = a gadfly).

The flies of this large family are commonly of stout build and large size, seldom very small. The big head is in the male almost wholly formed by the eyes, which meet across the crown; in the female also the eyes are large, but a narrow space is left between them, which generally bears a shiny streak or spot, known as the *callus*. In life the eyes are finely coloured, or iridescent, and marked with purple or brown bands or spots. The antennæ consist of 3 segments, the 3rd of which is composed of 4 to 8 subsegments incompletely fused together. The mouth-parts (Fig. 38) are

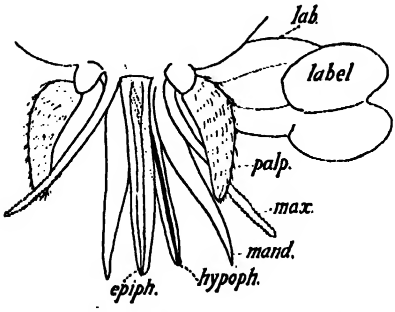

FIG. 38.—Mouth-parts of *Tabanus*.

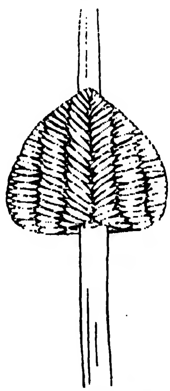

FIG. 39.—Egg-mass.

formed for stabbing and cutting; as a rule the labium is coarse and fleshy and the labella are large, the epipharynx and hypopharynx are dagger-shaped—the one being ventrally grooved, the other cannulate—the mandibles have the form of lancets, and the maxillæ are distally serrated. The maxillary palps, which are stiffly pendent on either side of the proboscis, consist of 2 segments, of which the 2nd is often large and tumid. The thorax and abdomen are clothed with short hair and are often rather soberly striped or banded or symmetrically marked. The abdomen is composed of 7 visible segments. The legs are stout, the pulvilli and empodium are large membranous plates. The wing-venation is shown in Fig. 6; the 3rd and 4th longitudinal

veins are forked, so that there are two submarginal and five posterior cells. The squamæ are large.

The eggs are laid in shapely masses (Fig. 39) on leaves and stems of plants growing in marshy ground or overhanging water. The larvæ live in wet earth, rotting vegetation, or in water, and are carnivorous; they are cylindrical in form, pointed at both ends, and have several prominent fleshy rings, or bands of pseudopods on the body. The pupa is much like a Lepidopterous pupa. According to Williston the whole term of development, embryonic and post-embryonic, occupies about eleven months.

The males of *Tabanidæ* are said to live on the juices of plants, but the females (of most, if not of all of them) are extremely blood-thirsty. Though they attack man freely, they do not—at any rate in most places—afflict him grievously as they do domestic animals; nor do they come much into dwelling-houses, nor are they known to transmit the infection of any specific disease of man, though they have been shown to transmit the surra trypanosome in India, and other pathogenic trypanosomes of domestic animals in Africa. The possibility of their infective agency in the case of man should, however, be always borne in mind.

The family is a large one, about 1600 species having already been described, and is represented in all parts of the world and at all altitudes. In the Pamirs, in 1895, a species of Tabanus was fairly abundant at a height of not less than 15,000 feet—on the grazing-grounds of *Ovis poli*.

The *Tabanidæ* are grouped in two subfamilies, namely: (1) *Tabaninæ*, in which there are no ocelli and no spurs on the hind tibiæ; and (2) *Pangoninæ*, in which there are spurs (though sometimes they are very inconspicuous) on the hind tibiæ, and ocelli are usually present.

Of the numerous genera of Tabanidæ the four most important are (1) *Tabanus* (*sensu latiore*), Fig. 40, in which the first 2 antennal segments are short, and the 3rd is angulated or spurred at its base, and is composed of 5 subsegments; (2) *Hæmatopota* (Figs. 41, 42), in which the 2nd antennal segment is short, and the 3rd, which is composed of 4 (occasionally 3) subsegments, is not angulated or spurred

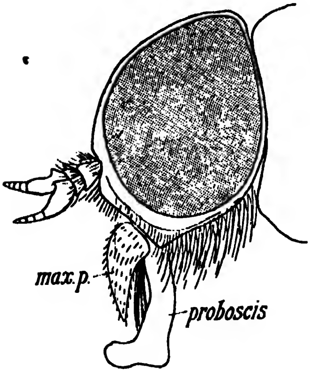

FIG. 40.—*Tabanus.*

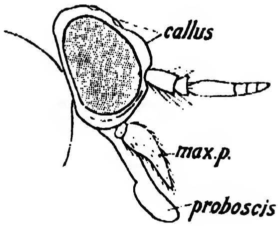

FIG. 41.—*Hæmatopota.*

FIG. 42.—*Hæmatopota.*

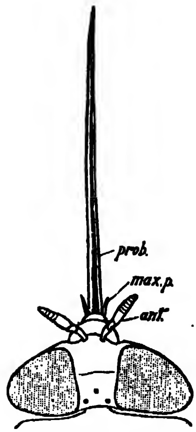

FIG. 43.—*Pangonia.*

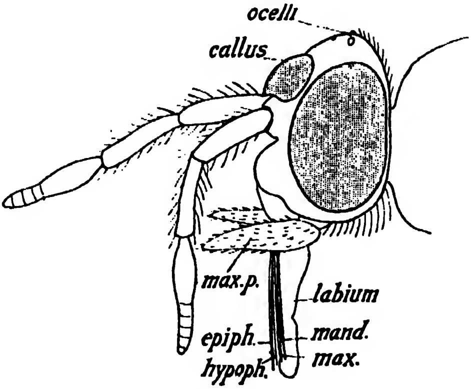

FIG. 44.—*Chrysops.*

at base, and the wings are profusely scribbled with fine curved markings; *Pangonia* (*sens. lat.*), Fig. 43, in which the 3rd antennal segment is composed of 8 subsegments and is not angulated or toothed at base, and the proboscis is usually elongate—being in some species several times longer than the body; and *Chrysops* (Fig. 44), in which all 3 segments of the antennæ are long, the 3rd segment being composed of 5 subsegments. All these genera are represented severally in all the great zoogeographical regions of the world, as also is the genus *Silvius*.

The following synopsis of the genera of *Tabanidæ* is taken from Miss Gertrude Ricardo's Revision of the family in the *Annals and Magazine of Natural History*, 1901-1904:—

Synopsis of Genera of Tabanidæ.

1. *Tabaninæ*.

1.	Third antennal segment composed of 4 subsegments or rings, and not angulated or spurred at base = 2.
	Third antennal segment composed of 5 subsegments or rings = 5.
2.	Rings so distinct that the whole antenna appears to consist of 6 segments *Hexatoma*, Meigen (Europe).
	Rings not so distinct as to modify the appearance of the antenna = 3.
3.	Wings with a profusion of ring-like and scroll-like markings HÆMATOPOTA.
	Wings not scribbled with circles and scrolls = 4.
4.	First and 2nd antennal segments pubescent in the male, 3rd segment longer than the 1st; eyes hairy = *Dasybasis*, Macquart (Chili and Australia).
5.	First antennal segment globose, situated on a frontal protuberance = *Bolbodimyia*, Bigot (Venezuela).
	First antennal segment not globose = 6.
6.	Third antennal segment not angulated or toothed at base = 7.
	Third antennal segment angulated or toothed at base = 9.
7.	Body covered with metallic scales = *Lepidoselaga*, Macquart [*Hadrus*, Perty] (South America).
	Body metallic in colouring = *Selasoma*, Macquart (South America).
	Body not in any way metallic; 1st antennal segment longer than is usual in *Tabanus*; wings usually with brown markings = 8.
8.	Antennæ long, the 3rd segment cylindrical and situated on a projecting tubercle = *Udenocera*, Ricardo (Ceylon).
	Antennæ not as particularised in *Udenocera* = *Diachlorus*, Osten Sacken (America and Philippines).

9. Abdomen short, stout, very convex = *Stibasoma*, Schiner (America).
Abdomen not as particularised in *Stibasoma* = 10.

10. Antennæ long and slender, the 1st segment long = *Acanthocera*, Macquart (South America).
Antennæ not as particularised in *Acanthocera* = 11.

11. Slenderer in build, usually with thorax and abdomen banded; 3rd antennal segment slender, wings mostly with brown markings = *Dichelacera*, Macquart (South America).
Stouter in build, 3rd antennal segment stout = TABANUS, L. (*sensu lat.*).

2. *Pangoniinæ.*

1. Third antennal segment composed of 8 or 7 subsegments or rings; proboscis usually elongate = 2.
Third antennal segment composed of 5 rings; proboscis short = 14.

2. Third antennal segment with a tooth *Dicrania*, Macquart (Brazil).
Third antennal segment with no tooth = 3.

3. Wings short; body flat, elliptical *Apocampta*, Schiner (Australia).
Wings not short = 4.

4. Third antennal segment with each subsegment branched *Pityocera*, Tos (Central America).
Third antennal segment not branched = 5.

5. Upper corner of eye terminating in an acute angle *Goniops*, Aldrich (North America).
Upper corner of eye not terminating in an acute angle = 6.

6. Antennæ deep-seated, inclined downwards; palpi very large *Cadicera*, Macquart (South Africa).
Antennæ and palpi not as particularised in *Cadicera* = 7.

7. Antennæ awl-shaped; end of proboscis hatchet-shaped; anal cell open and anal vein curved *Pelecorhynchus*, Macquart (Australia and South America).
Antennæ, proboscis, anal cell, etc., not as in *Pelecorhynchus* = 8.

8. Proboscis scarcely extending beyond palpi *Apatolestes*, Williston (California).
Proboscis extending beyond palpi = 9.

9. Wings with 4th posterior cell closed = 10.
Wings with 4th posterior cell open = 11.

10. Eyes bare *Dorcalæmus*, Austen (South Africa).
Eyes not bare *Scione*, Walker (South America, Seychelles, Australia).

11. Wings with 1st posterior cell closed = 12.
Wings with 1st posterior cell open = 13.

12. Eyes bare PANGONIA, Latr. (subgenus PANGONIA).
Eyes hairy PANGONIA, Latr. (subgenus *Erephrosis*, Rond.).

13. Eyes hairy DIATOMINEURA, Rond. (subgenus *Diatomineura*).
Eyes bare DIATOMINEURA, Rond. (subgenus CORIZONEURA, Rond.).

14. First and 2nd segments of antennæ short = 15.
First and 2nd segments of antennæ long CHRYSOPS, Meigen.

15. Second segment of abdomen unusually large, spurs of tibiæ small *Pronopes*, Loew (Cape of Good Hope).
Second segment of abdomen, etc., not as in *Pronopes* = 16.

16. Face concave in the middle *Rhinomyza*, Wied. (Cape of Good Hope and Java).
Face not concave in the middle = 17.

17. Wings with 1st posterior cell open SILVIUS, Meigen (subgenus *Silvius*).
Wings with 1st posterior cell closed SILVIUS, Meigen (subgenus *Esenbeckia*, Rond., Brazil).
Third segment of antenna with an acute spine *Gastroxides*, Saunders (India).

Family LEPTIDÆ (λεπτός = slender). The *Leptidæ* are a widely distributed family of dull-coloured flies showing considerable diversity of form. Many have a slender, tapering body, and long, slender legs, and some of these slender species are almost gnat-like in appearance. The form of the antenna is particularly varied; it may consist of 3 simple segments, either with or without a terminal or dorsal bristle; or of 3 segments with the 3rd compound as in *Tabanidæ;* or it may be coarsely nematocerous. The empodia are expanded. The wings are often blotched, and the venation is commonly like that of the *Tabanidæ;* but the squamæ are small or vestigial.

Some Leptidæ are predatory on other insects, and a few species (European and American) are known to suck blood. The larvæ are predaceous and those of one genus (*Vermileo*) make pitfalls in sand like the ant-lions.

Austen cites 4 blood-sucking species of *Leptidæ*, namely: *Symphoromyia* in America, *Leptis scolopacea* and *strigosa* in France, and *Trichopalpus obscurus* in Chili.

In *Symphoromyia* the antennæ are composed of 3 segments with an arista, the 3rd segment being kidney-shaped; the proboscis is short; the front tibiæ have no terminal spurs, and the hind tibiæ have a single spur; and the wing venation is like that of *Tabanidæ*, with the anal cell open.

Leptis differs from *Symphoromyia* in not having the 3rd antennal segment kidney-shaped, and in having two spurs on the hind tibiæ.

In *Trichopalpus* the proboscis is elongated.

Family ASILIDÆ: Robber-flies (Fig. 45), Lat. *Asilus* = a horse-fly). Usually bristly, elongate flies—but sometimes thickly hairy and bee-like—with remarkably long, strong, bristly legs. The head is broad and short, joined to the thorax by a very distinct and mobile neck, and deeply notched on the crown between the eyes. Antennæ composed of 3 simple segments, with or without a terminal bristle or style. Proboscis strong, chitinous, and pointed; formed for stabbing. Abdomen of 8 segments, with the genitalia conspicuous. Empodium bristle-like, or absent; pulvilli usually

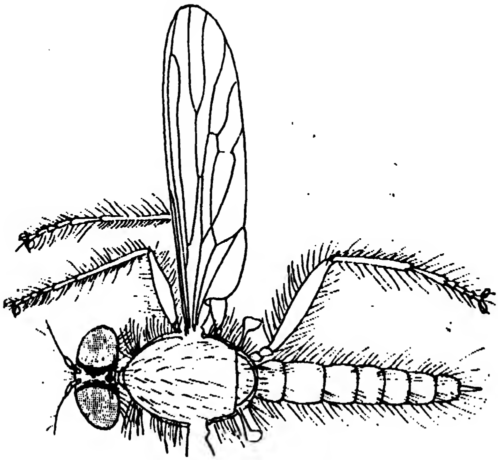

FIG. 45.—Robber-fly.

distinct, claws strong. Wing-venation complex, with two or three submarginal and five posterior cells. Squamæ small.

The Robber-flies are one of the largest families of Diptera, and are found in all parts of the world. Some of them are very large. They live entirely upon other insects, swooping upon them and impaling them with their proboscis, and then flying off with them clasped in their legs, to suck them at leisure. A robber-fly will often thus treat an insect much larger than itself. Robber-flies have been said to suck blood occasionally, and several medical officers from Africa have stated that they have been thus attacked, but this behaviour is not usual.

Family THEREVIDÆ (Θηρευεῖν = to hunt). The flies of this

family have some resemblance to small robber-flies, but the labella are fleshy (not pointed and chitinous), the legs are not so stout, and the crown of the head is not deeply notched between the eyes. They are predaceous and prey chiefly on other flies.

Family EMPIDIDÆ (ἐμπίς = a gnat). Usually dull-coloured flies of small size. The wing-venation is very variable, the 3rd and 4th longitudinal veins may be forked, and the anal cell may be large, or the venation may be as simple as that of a house-fly; sometimes there is no discal cell. Head spherical, eyes usually large. Antennæ of 2 or 3 segments, with or without a terminal style or a bristle which is usually terminal but may be dorsal. No fringe of bristles on the edge of the mouth. Proboscis short or long, usually rigid and formed for piercing. Thorax sometimes very convex. Legs usually slender; some of the segments may have a regular comb of spines, something like the raptorial legs of a *Mantis*. The family is a large one, and the species are predatory on other flies.

Family DOLICHOPODIDÆ (Fig. 46) (δολιχός = long; πούς = foot). Usually brightly metallic (often bright green) flies,

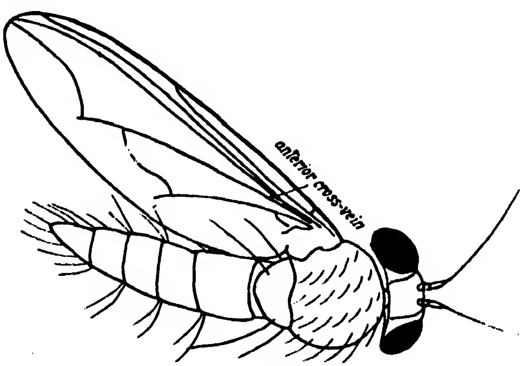

FIG. 46.—Dolichopodid Fly.

with long, slender legs. The wing venation is as simple as, or simpler than, that of a house-fly; the anterior cross-vein lies near the root of the wing; the anterior basal cross-vein is absent, so that the discal and 2nd basal cells are confluent;

and the posterior basal cross-vein and anal cell are often incomplete. Squamæ absent. Antennæ of 3 segments; the 3rd segment broad, with an arista which may be terminal, or more or less dorsal. Proboscis short and fleshy, palpi flat. The flies of this large family are predaceous. They haunt damp and shady places, or aquatic vegetation, or may even run on the surface of the water. Among some flies sent from Hongkong by Dr Atkinson as being predatory on mosquito-larvæ there were several specimens of a Dolichopodid.

Certain species of Brachycerous flies belonging in the families specified below have a long proboscis which may be mistaken for an apparatus for sucking blood.

(*a*) *Acroceridæ*. Flies with a very small head formed almost wholly by the eyes; the thorax and abdomen are large and inflated; and the squamæ are of peculiar magnitude. The larvæ about which anything is known are said to be parasitic on the young of spiders.

(*b*) *Nemestrinidæ*. Flies with a complicated wing-venation; the 4th and 5th veins curve forward and end in front of the tip of the wing; the empodia are broad, but the pulvilli are often minute.

(*c*) *Apioceridæ*. Flies of which some resemble *Asilidæ* and some in wing-venation resemble *Nemestrinidæ*. Empodia are absent.

All these three families are small, numerically.

(*d*) *Bombyliidæ*. The flies of this large family are as a rule thickly hairy, and many of them have a strong resemblance to bees. The head is often small and broadly sessile on the thorax. The wings often have dark markings, and the squamæ are small. The pulvilli and empodium are often vestigial. The antennæ commonly consist of 3 segments, but the 3rd is never compound. The *Bombyliidæ* are flower-flies; the larvæ of some species are parasitic in and on the larvæ and eggs of other insects, and certain species are said to do good service to man by destroying the eggs of locusts.

CHAPTER IX

Order Diptera (*continued*): The Aschiza

IN the flies of this division (Fig. 47) the frontal lunule is often indistinct and the frontal suture is not present at all. The antennæ are usually composed of 3 simple segments and an arista which is generally dorsal, rarely terminal. The 3rd longitudinal vein is not forked, and there are never more than three posterior cells in the wing. The empodia are not pulvilliform.

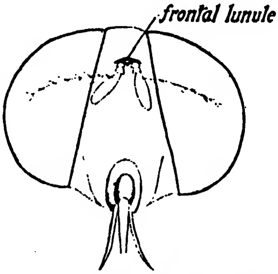

FIG. 47.—Head of a Syrphid Fly.

Four families are here included; not one of the species sucks blood, and few of them are of any importance from the medical standpoint.

Family SYRPHIDÆ, Hover-flies. Many of the species of this very large family are bright coloured, some of them resemble wasps and bees, and a few look like blue-bottles or green-bottles. They live on nectar and pollen, and are generally seen poised over or settled on flowers. The antennæ consist of 3 segments, usually with a dorsal arista. Between the 3rd and 4th longitudinal veins, more or less parallel with them, and crossing the anterior cross-vein, a

false longitudinal vein is nearly always present and is *a characteristic feature.* The head is sometimes elongated in the neighbourhood of the mouth, like a proboscis. The larvæ of certain species are aquatic, and have at the posterior end of the body (Fig. 48) a long breathing-tube

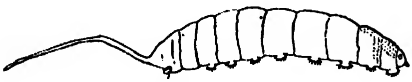

FIG. 48.—Rat-tailed larva of *Eristalis.*

which can be lengthened or shortened like a telescope to suit the depth of the water in which the larva finds itself. These larvæ, which are known as "rat-tailed larvæ," live in foul water; they are sometimes found in wells and occasionally have been ingested by human beings and subsequently passed by the bowel.

Family PHORIDÆ. (This family is sometimes classed with the Brachycerous Orthorrapha. In some of the species

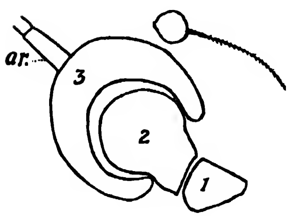

FIG. 49.—Antenna of *Apiochæta ferruginea:* the very much-enlarged lower figure in longitudinal section.

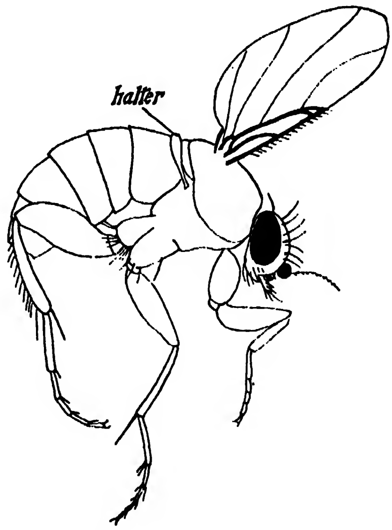

FIG. 50.—*Apiochæta ferruginea.*

the wings are much reduced in size, and in a few they are absent altogether.) The *Phoridæ* are small flies with humped back; strong, usually bristly, legs; and peculiar antennæ and wings. In the antennæ (Fig. 49) the 3rd

segment is globular, conceals the basal segments, and carries a long, terminal or subterminal, pubescent bristle. The wings, typically, are broad; their veins consist of two thick short longitudinal veins of normal disposition, and of three or four fine veins which run obliquely across the field of the wing (Fig. 50). The larva is a small maggot tapering anteriorly. The pupa is coarctate and boat-shaped. The larvæ live for the most part in decaying matter, animal and vegetable; some live in ants' nests either as parasites or merely as messmates.

The maggot of one species of this family, namely, *Apiochæta ferruginea*, is known as a sort of intestinal parasite of man, and is believed by Colonel Baker, I.M.S., to be able to complete its life-cycle, and to live as an adult capable of reproducing its species, in the human intestine. *Apiochæta ferruginea* (Fig. 50) is said by Austen to be very widely distributed in the tropics, having been sent to him from Burma, India, West Africa, Central America, and the West Indies.

The other two families of this group—PLATYPEZIDÆ and PIPUNCULIDÆ—are of no medical interest. Both of them consist of small flies having a wing-venation much like that of a house-fly, only with the second basal and anal cells usually larger. In the *Platypezidæ* the hind-legs are thickened, particularly as to the tarsal segments; the larvæ live in fungi. In the *Pipunculidæ* the head is subglobose, relatively enormous, and is formed almost wholly by the eyes.

CHAPTER X

Order Diptera (*continued*): Schizophora: The Muscoidea

IN the flies of this division, the frontal lunula is distinct and there is a frontal suture (Fig. 10). The antennæ consist of 3 simple segments and an arista which is almost always dorsal. None of the longitudinal veins is forked. Two groups are here included, namely, the *Muscoidea*, of which the house-fly is a type, and the *Pupipara*, or "Tick-flies." As a rule, to which, however, there are exceptions, the *Muscoidea* lay numerous eggs, and these give rise to maggots more or less similar to that represented in Fig. 53, whereas the *Pupipara*, so far as is known, produce—one at a birth—full-grown larvæ on the verge of pupation.

A. The MUSCOIDEA, or EUMYIDEA.

The families of Muscoidea are arranged in two series, namely (a) *Muscoidea Acalyptrata* (ἀ privative, and καλύπτρα = a cover), in which the squamæ are so small that they do not conceal the halteres in a dorsal view, and (b) *Calyptrata* (καλύπτρα = a cover), in which the squamæ are so large that they conceal the halteres.

(a) *Acalyptrate Muscoidea.*

There are more than twenty families of *Acalyptrata*, of which only the following need be noticed:—

Family CONOPIDÆ. Elongate flies commonly with a constricted "waist," and often resembling wasps and bees. The wing-venation is much like that of a house-fly, but the basal and anal cells are all large. The genitalia are conspicuous. The proboscis is slender and elongate, but is used for extracting nectar from flowers, not for sucking

blood. The female deposits her eggs on bees and wasps, in which the larvæ when hatched become parasitic. By some authors this family is included with the *Aschiza*.

Family *Sepsidæ* (Fig. 51) (σῆψις = putrefaction). Small, usually black flies, with round head and constricted "waist." The auxiliary vein is often indistinct, and the wing commonly has a dark spot, or spots, near the tip. The *Sepsidæ* are quick in flight, and run with great activity; they may be found on decaying animal and vegetable matter, in which they lay their eggs. The maggots of *Piophila* live in cheese and bacon, and may be recognised by their power of leaping

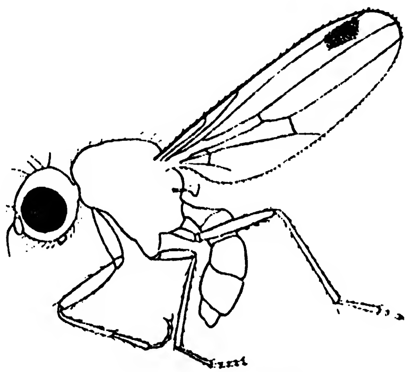

FIG. 51.—A Sepsid Fly.

or skipping; they have been found in the pharynx and intestine of man, having probably been ingested in cheese.

Family OSCINIDÆ. Small, bare, lightish-coloured flies with a very simple wing-venation, there being no auxiliary vein, no discal cell, and no anal cell. A small species of *Oscinis* which often hovers about the eyes is said by Castellani to be the cause of severe conjunctivitis.

Family TRYPETIDÆ. Small flies with very elegantly dappled wings and wing-venation like an Anthomyid (Fig. 69). The larvæ are found in vegetables and fruit, to which they may cause much damage.

Family CORDYLURIDÆ (Scatophagidæ). The flies of this family are among the largest of the Acalyptrate Muscids; their wing-venation is like that of an Anthomyid, but the abdomen is always composed of more than 4 visible segments,

and the squamæ are small. These flies are often found on excrement, and some of them are predaceous on flies and other insects.

(b) *Calyptrate Muscoidea.*

The squamæ are large and generally conceal the halteres in a dorsal view; the subcostal vein is distinct, and the 1st longitudinal vein is of good length; the scutum is completely bisected by a transverse suture in front of the wings; generally in the male the eyes are approximated. This division includes an enormous number of species, many of which are of importance to the sanitarian and pathologist; they are often grouped in six "families," which, however, are not always quite clearly defined one from another and are not universally recognised. The following table is taken from Williston's *North American Diptera*:—

Synopsis of Families of Calyptrate Muscoids.

1.	Mouth and mouth-parts small or vestigial	*Œstridæ.*
	Mouth and mouth-parts well formed	= 2.
2.	Hypopleura with a tuft of bristles; 1st posterior cell narrowed or closed	= 3.
	Hypopleura with no tuft of bristles; 1st posterior cell narrowed or fully open	= 6.
3.	Arista usually bare, sometimes pubescent; body and legs very bristly	*Tachinidæ.*
	Arista feathered or distinctly pubescent	= 4.
4.	Arista feathered, but not to the tip; discal bristles rarely present on the *anterior* segments of the abdomen	*Sarcophagidæ.*
	Arista feathered or pubescent to the tip	= 5.
5.	Abdomen usually with discal bristles on its anterior segments; legs usually long	*Dexiidæ.*
	Abdomen with no discal bristles; arista feathered	*Muscidæ.*
6.	First posterior cell narrowed or closed; arista feathered to tip	*Muscidæ.*
	First posterior cell slightly or not at all narrowed; arista feathered, pubescent, or bare	*Anthomyidæ.*

Family MUSCIDÆ (*sensu restricto*).

To the medical officer this is one of the most important of all the families of insects, as it includes a considerable number of dangerous pests of man, of which the house-fly is the best known, and the tsetse-fly is, perhaps, the most notorious and most formidable.

The species may be hairy or not, but they are never thickly covered with bristles and never have discal bristles (see p. 41) on the abdomen. The arista is almost always plumose to the tip.

From our practical point of view it is convenient to deal with the Muscidæ in two lots, according to the manner in which they affect man.

1. *Muscidæ which do not, as Adults, suck Blood.*

Of these some, like the house-fly and blow-fly, are harmful to man by carrying infection directly and mechanically, or by polluting food and drink, in the ways already mentioned (p. 32).

Others, like the green-bottles and the notorious screw-worm fly, also may deposit their eggs in foul wounds or in the natural orifices of the body of man and animals, whence their larvæ (maggots) may burrow into the tissues, and if they get into the bony cavities of the head may do mortal hurt.

The maggots of one genus (*Cordylobia*) are habitually subcutaneous parasites of man and domestic animals. Those of another genus (*Auchmeromyia*) have much the habits of bed-bugs, hiding by day and coming out at night to suck the blood of sleepers.

With regard to the species whose maggots get into wounds or invade the natural openings of the body (commonly the nostrils), it need hardly be mentioned that they are not likely to get a footing in healthy and vigorous adults of clean habits. The sufferers are generally either careless or dirty people, or lepers, or wounded men who have been neglected, or people with very foul breath—incompetent people, in short, whose odour also is so sufficiently like that of the decomposing matter in which the fly naturally lays its eggs as to mislead the insect. The treatment for maggots that have burrowed from the nasal passages into the sinuses of the head, devouring all before them, is free and frequent irrigation with some powerful and volatile antiseptic lotion, or with a strong solution of quassia and salt; chloroform-water is recommended by some, or an emulsion of chloroform and turpentine in a watery solution of boracic

acid, and, for the fearful stench, a solution of permanganate of potash.

It has to be remembered that house-flies and blow-flies, which the civilised man—who does not and cannot live according to nature and the recommendations of Stoic philosophy—has now learned to regard as dangerous, are, from the *natural* point of view, by no means *altogether* a curse. Their maggots are unceasing scavengers, consuming a vast amount of unconsidered filth, and if they are kept in their proper place, quite remote from dwelling-houses, may do good service in parts of the world where sanitation is of a primitive kind.

In the Muscidæ which we are now considering the arista is feathered both dorsally and ventrally; the 4th longitudinal vein is bent abruptly forwards at an angle, so as nearly to close the 1st posterior cell; and the proboscis (Fig. 10) is broad, for the most part soft and retractile, and ends in large fleshy expansile labella. In each labellum there is a radiating arrangement of numerous tubules which in structure and appearance resemble tracheæ: these, which are known as *pseudotracheæ* (Fig. 3), open on the under surface of the labellum and are used for absorbing nutriment, their bases being furnished with Y-shaped teeth for abrading the food. The other features of the proboscis are represented in Fig. 3.

There are numerous genera of Muscidæ which are domestic pests; the commoner genera, which the medical officer should be able to recognise, may be tabulated as follows:—

Table of Important Genera of Muscidæ. A.

1.	Hypopleura without any tuft or comb of bristles; tibiæ of middle legs without any bristle near middle of inner surface	*Musca.*
	Hypopleura with a vertical row of bristles; tibiæ of middle legs with a large bristle or bristles near middle of inner surface	= 2
2.	Thorax and abdomen bluish-black, not lustrous; cheeks hairy	*Calliphora.*
	Thorax and abdomen green, or bluish-green, or bronze-green, and of a brilliant metallic lustre; cheeks not thickly hairy	= 3.
	Thorax and abdomen dirty brownish-yellow, cheeks very sparsely pubescent	= 5.

3. { Scutum longitudinally striped — *Chrysomyia.*
   { Scutum not longitudinally striped — 4.

4. { Thorax and abdomen metallic green or bluish-green — *Lucilia.*
   { Thorax and abdomen more brassy green or purplish-blue, the posterior margin of some of the abdominal segments blackish — *Pycnosoma.*

5. { Eyes wide apart in both sexes; 2nd abdominal segment of female more than half the total length of the abdomen — *Auchmeromyia.*
   { Eyes of male close-set; 2nd abdominal segment of female not inordinately long — *Cordylobia.*

Genus Musca.

The species of this cosmopolitan genus are of smallish size and dull colour—the thorax being blackish-grey and the abdomen yellowish. The arista is feathered both dorsally and ventrally. The proboscis is soft and retractile and ends in large fleshy labella. The 4th longitudinal vein bends forwards at an abrupt angle so as nearly to close the 1st posterior cell (Fig. 5). There is no tuft or comb of bristles on the hypopleura, and no large bristle on the inner surface of the tibiæ of the middle legs.

Musca domestica, L., the common house-fly, is a species which is found in all parts of the world. The head is dark, with a velvet-black frontal stripe. The scutum is dusted with grey and marked sometimes rather indistinctly with four equidistant black stripes of equal breadth. The abdomen is yellow, with a median dark stripe and a dark tip. In the male the eyes are set close together, in the female they are wide apart.

In very hot countries the house-fly has no particular season and breeds more or less all the year round. In colder countries it is abundant during the summer and autumn, but—except for a few individuals that survive in sheltered spots—dies out with the approach of winter. The survivors of the winter, as well as new individuals that emerge from pupæ which have hibernated, soon increase their kind as the weather becomes warmer.

The habits of the house-fly are only too well known, and the malign influence of this insect as an infective agent has already been considered (p. 32).

The breeding-habits of the house-fly have been observed with great care both in tropical and temperate latitudes. The female lays from 120 to 150 eggs in a batch, in rubbish of any sort provided it is fairly moist. Stable-sweepings are a favourite nidus, but any kind of excrement rich in vegetable debris is good enough, or any kind of house-refuse, even rotting paper, or even, according to Williston, the contents of smokers' spittoons.

The eggs are white, sticky, and shiny, resembling those of the blow-fly (Fig. 52) on a smaller scale. They hatch within twenty-four hours in hot weather, but may take three or four days to develop if the weather be cool.

The larva or maggot is whitish and, except that it is smaller, much resembles that of the blow-fly (Fig. 53). It is cylindrical, tapering anteriorly, blunt posteriorly, and consists of 12 segments besides a minute head hardly visible to the naked eye. The head, in fact, is formed chiefly by a pair of papillæ (antennæ). Immediately behind these papillæ lies the mouth, from which the tips of a pair of large, black, chitinous mandibles project; these are used for tearing and burrowing into the food-material. At the blunt posterior end there is a pair of large, depressed, chitinous plates—the *stigmata*—on which the main tracheal trunks open by three slits. A second, much smaller, pair of stigmata project from the sides of the 2nd segment in well-grown larvæ. The larva feeds on the decomposing refuse in which it is hatched. In the tropics, in the hot season, it becomes full grown in about five days; in England it may in hot weather attain its full development in a week, but if the summer temperature be low it may take six to eight weeks.

When the larva is full grown it leaves its food and contracts to an elongate barrel shape; its skin becomes hard, and gradually changes in colour from dirty white to dark brown or black; and inside this firm larval shell, or *puparium*, the pupa is formed. The pupal stage lasts about three days in the tropics; but in temperate climates its duration depends entirely on the weather, from a week in warm weather, to a month or more in inclement weather. The manner in which the adult fly emerges from the pupal case is illustrated in Fig. 9.

Thus, in the tropics the whole term of development from egg to adult may be fulfilled in about ten days, and in a hot summer in England in about a fortnight; but under unfavour-able conditions of temperature it may continue for nearly three months.

In dealing with the house-fly as a pest, gauze and fly-papers are merely palliatives. The way to suppress flies is, as with mosquitoes, to make a clean sweep of breeding-places. House refuse, street sweepings, and rubbish of all sorts should be incinerated, or, if this be impossible, should be carted several miles from centres of population and dumped to leeward of prevalent winds. Latrine-stuff should be buried deep enough to prevent any emergence of flies from maggots that may have got into it at the source. Horse-dung required for use should be shot far from the house and treated with quick-lime, and the heap should be forked and spread frequently so that fowls and wild birds may get at any maggots and pupæ that it may contain. Colonel Thornhill emphasises the necessity of using infinite care in carting away filth to trenching-grounds; if it be allowed to drip from the carts the whole route becomes a breeding-ground for flies.

Genus *Calliphora*: Blue-bottles, or Blow-flies. The species of this cosmopolitan genus are larger than those of *Musca*,

FIG. 52.—Egg of Blow-fly.

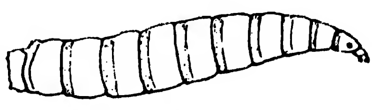

FIG. 53.—Larva of Blow-fly.

and are of a blue-black or black colour. The cheeks are broad and hairy; there is a vertical row of bristles on each hypopleuron; and there are bristles on the inner edge of the tibiæ of the middle legs. Blow-flies are particularly attracted to meat and offal, on which they lay their eggs (Fig. 52) in sticky clusters. It is possible that they may sometimes deposit their eggs in foul wounds, or in the nostrils of the living subject; or that their eggs or maggots may be swallowed in food and may thus get into the bowel. Fig. 53 represents the maggot, and Fig. 54 the pupa, enlarged. The

course and duration of development is much the same as that of the house-fly.

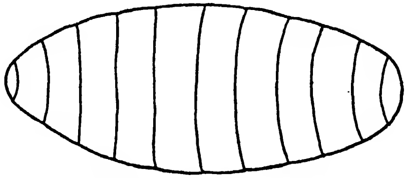

FIG. 54.—"Pupa" of Blow-fly.

Genus *Lucilia.* The species, which are widely distributed, resemble those of *Calliphora* in form and habits, but are of a brilliant metallic green or bluish-green colour, and have much less hairy cheeks. The eggs and maggots much resemble those of *Calliphora* and are deposited in similar places, and the course of development is the same.

Genus *Pycnosoma* (πυκνός = thick; σῶμα = body). The species are found in Tropical Africa and Tropical Asia. They resemble those of *Lucilia,* but usually have a rather stouter body, are of a more coppery tinge and have the hinder edge of some of the abdominal segments black, giving the abdomen a cross-banded appearance. The maggots of a species of *Pycnosoma* have actually been known to get into the nostrils of living people and to burrow into the contiguous sinuses, causing great pain; but ordinarily the habits and development are like those of *Calliphora.*

Genus *Chrysomyia* (χρυσός = gold; μυῖα = fly). The species are restricted to America and are distinguished from those of *Lucilia* by the dark longitudinal stripes on the scutum. *Chrysomyia macellaria,* Fabr., is the well-known Screw-worm-fly which is a common cause of myiasis in Tropical America, the maggots having been found in wounds, in the nasal passages, and even in the urethra. The maggots have a general resemblance to those of *Calliphora* (Fig. 53), but the constrictions between the segments are more strongly marked and the bands of spines are more salient, the spines themselves being much coarser. The maggots, of course, like those of *Calliphora,* etc., are *usually* found in putrid animal matter.

Genus *Auchmeromyia* (αὐχμηρός = sunburnt, or dirty;

μυῖα = fly). One species has been described, *A. luteola*, from Tropical Africa. It resembles a blow-fly in everything but colour, which is a dirty yellowish-brown with the after part of the abdomen rusty black. The female is easily recognised by the great length of the 2nd abdominal segment. The larva, which is known as the Congo Floor Maggot, lives in the mud floor of native huts and comes out at night to suck the blood of people sleeping on the ground. It differs from other Muscid maggots in being somewhat broader and flatter, and in its much more wrinkled surface (Fig. 55).

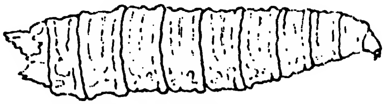

FIG. 55.—Larva of *Auchmeromyia*.

Genus *Cordylobia* (κορδύλη = a bump, or tumour; βίος = way of life). This genus, of which three species have been described, is also peculiar to Africa. The notorious species is *Cordylobia anthropophaga*, Grünberg (the Tumbu-fly), the larva of which is a subcutaneous parasite of man and other

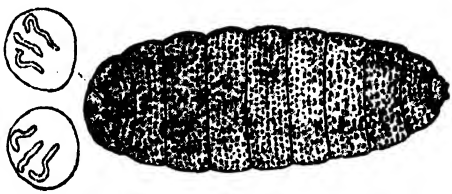

FIG. 56.—Larva of *Cordylobia*.

animals in many parts of Africa. The adult fly is very much like *Auchmeromyia luteola*, but in the male the eyes are set close together, and in the female the 2nd abdominal segment is not of any remarkable length. The maggot (Tumbu, Fig. 56) is plumper and more barrel-shaped than other Muscid maggots and is more or less completely covered with small spines which are grouped in twos and threes, and the breathing-slits of the stigmata on the last segment of the body are of a very peculiar shape (Fig. 56). The presence of the maggot occasions the formation of a boil, in the centre of which there is an opening through which the maggot

breathes, and many such boils, each containing a maggot of the same age, may occur simultaneously in the same patient. How the maggot reaches its station under the skin is not known with certainty. According to Major F. Smith, the natives of West Africa believe that the fly deposits its eggs on the ground and that the young larvæ penetrate the skin of people sleeping on the ground; according to Major A. P. Blenkinsop, it is a common opinion in West Africa that, in the case of Europeans, the parasites are acquired at the latrine; according to Mr Austen, the belief among Europeans in Rhodesia is that the fly lays its eggs on woollen clothing hung out to dry.

CHAPTER XI

Muscidæ (*continued*): The Blood-sucking Muscidæ

2. *Blood-sucking Muscidæ.*

IN the majority of the blood-sucking *Muscidæ* the proboscis (Figs. 58, 60, 65) is strongly chitinised and rigid, is little or not at all retractile, and is more or less slender and tapering, and the labella are small, stiffly chitinised, and serrated or spinose (Fig. 57), so that the proboscis forms a very efficient augur for piercing epidermis. Occasionally, however, the proboscis is only partly chitinous and is fully retractile, and the labella are large and fleshy, but even in this case strong teeth capable of cutting through skin are present. In other respects the proboscis resembles that of other Muscidæ, being

FIG. 57.—Labella of *Stomoxys*.

longitudinally grooved on its dorsal surface so as to ensheathe the epipharynx and hypopharynx, which together form a tube by apposition and basal interlocking. As in other Muscidæ, mandibles and maxillæ are absent. The blood-sucking habit is not confined to the female, but characterises both sexes equally.

As regards their connection with disease; as, with the glaring exception of *Glossina* and perhaps of *Stomoxys*, none of them *habitually* attacks man, they are not—*Glossina* being, of course, the notorious exception—likely to be the ordinary and necessary agents of any human infection, though of course they must all be regarded with suspicion as fortuitous or at least potential "carriers." In the case of domestic

animals, however, they are something more than casually harmful, since several of them besides *Glossina* have been proved to "carry" dangerous pathogenic micro-organisms.

As regards their method of breeding: that of *Glossina* is distinct, and is remarkably like that of the Pupipara; but in all the other blood-sucking Muscidæ the breeding habits and mode of reproduction, so far as is known, are like those of the house-fly, and the usual pabulum of the larvæ is the dung of herbivorous animals.

Table of Blood-sucking Muscidæ.

1. Arista feathered dorsally only, the individual hairs being also feathered. Proboscis with a bulbous base and very slender shaft. Maxillary palps long and slender, embracing the proboscis like a sheath. Fourth longitudinal vein curved in its proximal portion, so as to enlarge the anterior basal cell distally and to contract the discal cell basally; and sharply bent forwards in its distal portion in line with the posterior cross-vein, so as nearly to close the 1st posterior cell at a point much anterior to the tip of the wing. Abdomen composed of 7 visible segments *Glossina.*
   Hairs of arista not feathered. Shaft of proboscis not remarkably slender. Maxillary palps not forming an obvious sheath for the proboscis. Fourth longitudinal vein not remarkably sinuous in its proximal portion, and curved or bent forwards in its distal portion at a point considerably beyond the posterior cross-vein. Abdomen composed of 4 visible segments = 2

2. Maxillary palps slender, less than half the length of the proboscis. [Arista feathered dorsally only. Third longitudinal vein with some bristles on its proximal part] = *Stomoxys.*
   Maxillary palps more or less spatulate, almost as long as the proboscis, or at any rate very much more than half its length = 3.

3. Proboscis chitinous in all its extent, the labella small = 4.
   Proboscis with the distal part (and the large labella) fleshy. [Arista feathered dorsally and ventrally: 3rd longitudinal vein not bristly: 4th longitudinal vein abruptly bent as in *Musca* so as nearly to close the 1st posterior cell] = 8.

4. Arista feathered dorsally only = 5.
   Arista feathered dorsally and ventrally = 6.

5. Proboscis long and tapering: 4th longitudinal vein gently curved in its distal part so as to leave the 1st posterior cell widely open: 3rd longitudinal vein without bristles = *Lyperosia.*
   Proboscis short and stumpy: 1st posterior cell narrowly open: 3rd longitudinal vein with some bristles proximally = *Stygeromyia.*

6. Fourth longitudinal vein strongly curved distally, so as to leave the 1st posterior cell narrowly open. [Third longitudinal vein without bristles] = *Hæmatobosca.*
Fourth longitudinal vein gently curved distally, so as to leave the 1st posterior cell widely open = 7.

7. Third longitudinal vein with some bristles proximally = *Hæmatobia.*
Third longitudinal vein without bristles = *Bdellolarynx.*

8. Terminal fleshy part of proboscis reflexed beneath the chitinous part in repose *Philæmatomyia.*
Terminal fleshy part of proboscis not reflexed in repose (?) *Pristirhynchomyia* (?).

Stomoxys, Geoffroy (στόμα = mouth; ὀξύς = sharp). The numerous species of this cosmopolitan genus much resemble the house-fly in general appearance, but are readily distinguished by the black, shiny, tapering, stiff proboscis (Fig. 58), by the absence of hairs from the lower edge of the

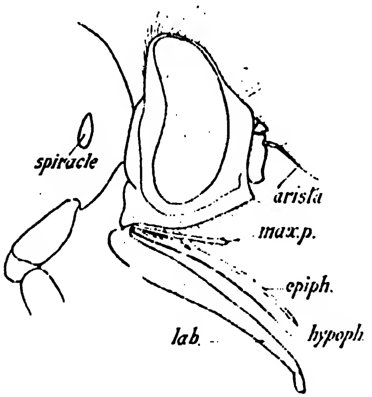

FIG. 58.—Head of *Stomoxys*.

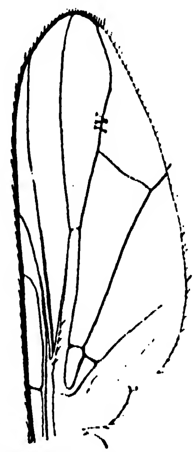
FIG. 59.—Wing of *Stomoxys*.

antennal bristle, and by the gentle curve of the 4th longitudinal vein (Fig. 59). They not infrequently come into houses and bite man, but their usual victims are domestic animals, and their ordinary haunts are stables, farmyards, and pastures.

Stomoxys calcitrans, L., the type of the genus, is said by Austen to occur throughout the greater part of the world. To casual view it looks like a house-fly, but it has six or seven

symmetrically-arranged, dark, round spots on the dorsum of the abdomen. It generally deposits its eggs in horse-dung, but also, according to Newstead, whose account of its development is here summarised, in musty grass-mowings.

A female lays from 50 to 70 eggs, which are white, and are shaped somedeal like a banana with a broad groove along the shorter and straighter curvature: in warm weather they hatch in two or three days. The larva and pupa are not remarkably different from those of other *Muscidæ* (*cf.* Figs. 53, 54); the larva becomes full grown, if the pabulum be warm and moist and protected from light, in fourteen to twenty-one days; the pupal stage in Newstead's observations lasted nine to thirteen days. In unfavourable conditions, such as cold, drought, and exposure to bright light, the developmental stages are said by Newstead to be prolonged.

Hæmatobia, Robineau-Desvoidy (αἷμα = blood; βίος = way of life). In distribution, habits, and general appearance similar to *Stomoxys*, from which it is distinguished (Fig. 60)

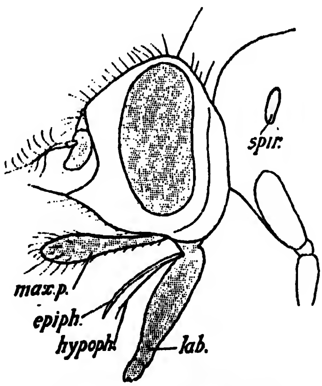

FIG. 60.—Head of *Hæmatobia*.

by the smaller head, by the shorter and rather coarser proboscis, by the long spatulate maxillary palps, and by the presence of a few hairs on the lower border of the antennal bristle. As in *Stomoxys* there are a few bristles at the proximal end of the 3rd longitudinal vein.

Lyperosia, Rondani (Fig. 61) (λυπηρός = troublesome). In distribution and habits similar to *Stomoxys*, but not much

more than half the size. The proboscis is long and rather slender, the maxillary palps are broad and as long as the proboscis, there are no hairs on the lower border of the antennal bristle, and the 4th longitudinal vein is gently curved beyond the cross-vein. Fig. 61 represents a female *Lyperosia* full of eggs and with ovipositor protruded, seen as a transparency mounted in balsam. The eggs of *Lyperosia irritans*, L., are said to be deposited on fresh cow-dung and to be reddish-brown in colour.

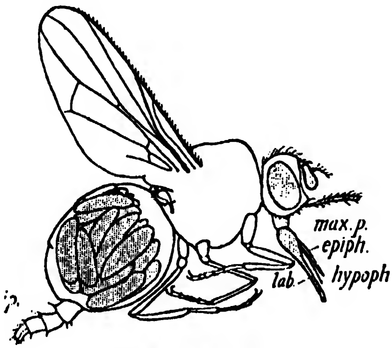

FIG. 61.—*Lyperosia.*

Hæmatobosca, Bezzi (αἷμα = blood; βοσκεῖν = to feed). Represented in Europe, North India, and China. As in *Hæmatobia* the arista has a few hairs on its lower border, and the maxillary palps are spatulate and as long as the proboscis; but the 4th longitudinal vein is strongly curved distally so as to narrow the 1st posterior cell very much, and there are no bristles on the 3rd longitudinal vein.

Stygeromyia, Austen (στυγερός = hateful; μυῖα = fly). Known from Arabia and Tropical Africa, and resembles *Stomoxys* in general appearance. The arista is feathered on the upper border only, the proboscis is remarkably short and stout, the maxillary palps are spatulate and as long as the proboscis, the 3rd longitudinal vein has a few bristles at its proximal end, and the 4th longitudinal vein is strongly bent distally.

Bdellolarynx, Austen (βδελλο-λάρυγξ = a greedy parasite, lit. leech-throat). From India and Ceylon. Resembles *Hæmatobia*, but the shape of the head is different, the hairs

on the lower border of the arista are more numerous, and the 3rd longitudinal vein is bare.

Philæmatomyia, Austen (φιλάιματος = bloodthirsty; μυῖα = fly). From India, Ceylon, Tropical Africa, and Cyprus. Resembles the common house-fly in general appearance, having the arista feathered on both borders, the 4th longitudinal vein bent at an angle (*cp.* Fig. 5), and the proboscis coarse and retractile. The maxillary palps, however, are spatulate and are not much shorter than the proboscis. Austen has described and figured the curious proboscis, which, however, here (Fig. 62) is shown as seen by transmitted

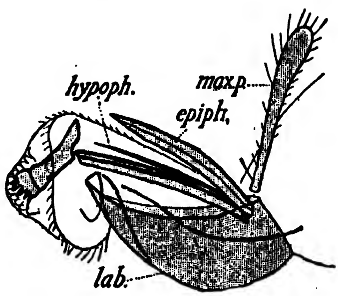

FIG. 62.—Mouth-parts of *Philæmatomyia.*

light after maceration in caustic potash. It consists of a boat-shaped chitinous basal part and a shorter terminal soft portion (with large labella and numerous pseudotracheæ) which, in repose, is bent back beneath the chitinous shaft. Besides the powerful epipharynx and the hypopharynx there is a pair of stout chitinous rods, to which is hinged a massive chitinous terminal-piece crowned with large teeth. In action the fleshy portion of the proboscis is erected and extended, carrying the toothed terminal-piece with it.

Pristirhynchomyia, Brunetti, from Calcutta, seems to be identical with the earlier described *Philæmatomyia*, the supposed difference in the proboscis seeming to be a misconception.

Genus GLOSSINA, Wiedemann: Tsetse-flies.

The genus *Glossina* is distinguished from all other *Muscidæ* by certain peculiarities of the antennæ, of the wing venation, and of the method of reproduction—peculiarities so decided

as in the opinion of some people to justify the formation of a separate family for the genus. From other blood-sucking *Muscidæ Glossina* further differs in the form of the proboscis and maxillary palps, and in the structure of the abdomen and *hypopygium*, or modified segments that compose the external genitalia of the male.

The *antennæ* in both sexes contain in their 2nd and 3rd segments a sensory labyrinth the general appearance of which, as seen in a "cleared" specimen under a low power, is shown in Fig. 63. The central vesicle of this organ opens

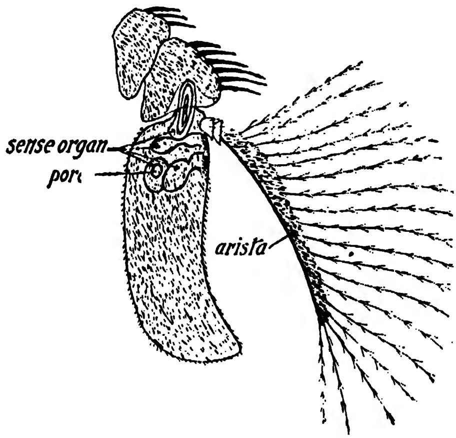

Fig. 63.—Antenna of *Glossina*.

by a small pore on the inner surface of the 3rd segment. The labyrinth is lined with large flagellated cells which somewhat resemble auditory-cells.

The *antennal arista* (Fig. 63) is broad and compressed, is feathered on its anterior (dorsal) edge only, and the individual hairs of the plume are themselves feathered.

In the *wings* (Fig. 64), the 4th longitudinal vein is strongly curved in its proximal portion, and is again strongly bent forwards at the junction with the posterior cross-vein. The first curve enlarges the anterior basal cell distally at the expense of the discal cell, which is correspondingly contracted proximally. The second bend very much narrows the first posterior cell at a point much anterior to the tip of

the wing. Further, the anterior cross-vein is more than ordinary oblique.

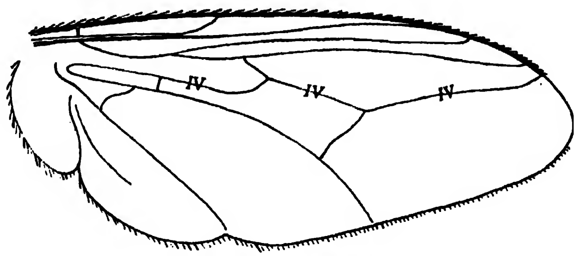

FIG. 64.—Wing of *Glossina*.

The *proboscis* (Fig. 65), which is chitinous and projects horizontally, consists of a bulbous base which contracts abruptly to a long and very slender shaft. As in other *Muscidæ* it is longitudinally grooved dorsally to hold the

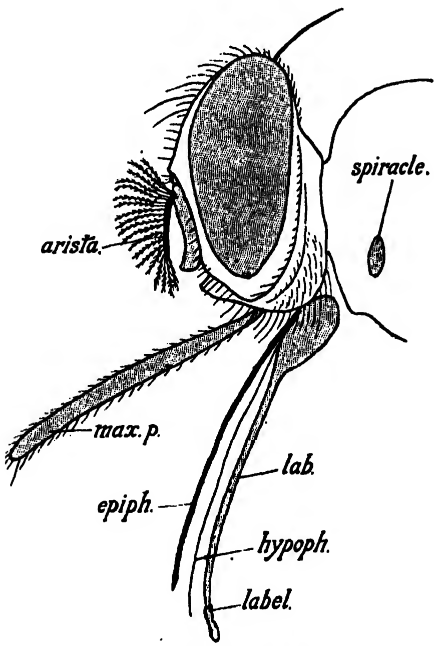

FIG. 65.—Head of *Glossina*.

needle-like epipharynx and the tubular filamentous hypopharynx (Fig. 65); the two last organs form by apposition and basal interlocking a suctorial tube.

The *maxillary palps* (Fig. 65) are slender, and are as long as the proboscis, to which, in repose, they are applied so as to form a sort of loose sheath.

The *hypopygium* of the male (Fig. 66) has the form of a large oval-swelling lying upon and in great part concealing the ventral surface of the 7th abdominal segment. The anal slit bisects the swelling anteriorly, and gives the organ somewhat the appearance of the pudenda (muliebria). In front of the hypopygium, on the venter of the 6th segment, is a pair of smaller tumours, which Austen, with deplorable irreverence to the ghosts of the heroes, has named Hectors. When the hypopygium is turned back it is seen to consist of

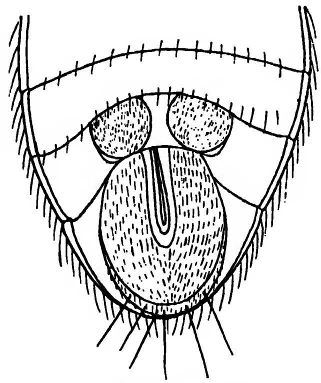

FIG. 66.—Hypopygium of male *Glossina*

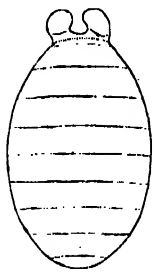

FIG. 67.—Pupa of *Glossina*.

a "nest" of 3 highly modified segments, the outermost of which carries a pair of large claw-like or talon-like claspers.

The *method of reproduction*, which was discovered by Sir David Bruce, is like that of the *Pupipara*. The female bears a single larva at a time, retaining it and nourishing it within the oviduct until it is full grown. Immediately the larva is born it seeks refuge in the ground and transforms to a pupa. The larva is of a yellowish-white colour, is composed of the usual 12 segments, and has a finely granular cuticle; at its posterior end there is a pair of large dark-coloured knuckle-like protuberances, in a depression between which lie the spiracles. The pupa (Fig. 67) is broadly ovoid in shape, with the posterior larval protuberances persistent, and is usually of a dark brown colour.

As regards other features of the genus *Glossina*, the eyes are large, and in both sexes are well separated; the mesonotum is generally marked in the manner illustrated in Fig. 68, though some of the markings are in some species indistinct; and the abdomen is composed of 7 visible segments, not including those that form the hypopygium.

In repose tsetse-flies are distinguished from other blood-sucking *Muscidæ* by the fold of the wings and by the poise of the proboscis. The wings are closed horizontally so that one lies above the other, and the proboscis projects horizontally.

According to Stuhlmann one species of *Glossina* may occasionally produce larvæ parthenogenetically.

Other blood-sucking *Muscidæ* (like the *Culicidæ*) appear,

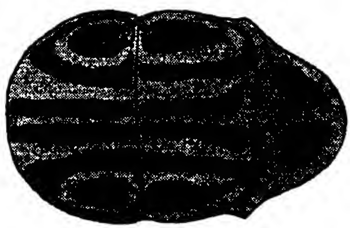

FIG. 68.—Colour-scheme of Mesonotum of *Glossina*.

though preferring blood, to be able to subsist on other juices, but blood is said to be a necessity of life for tsetse-flies.

As regards their geographical distribution the flies of this genus are restricted to the Ethiopian Region (p. 7), and in that region there is only one species that is known to exist outside continental Africa, namely, *G. tachinoides*, which has been found in the south-west corner of Arabia. The range of the genus in Africa extends from about 18° N. to about 31° S. Within these limits *Glossina* is usually confined to warm and damp situations, not very far distant from water, where shade of some kind—of forest, or of scrub, or at least of reeds—is obtainable, such natural stations being usually known as "fly-belts." Tsetse-flies are said to be absent from open shadeless plains.

The connection of tsetse-flies with certain trypanosome scourges of man and domestic animals, the elucidation of which has made the names of David Bruce and Kleine as

"familiar in men's mouths as household words," needs no general preface in a text-book of entomology that is intended for medical officers. Until lately some medical officers were inclined to think that the only species that they need trouble about was *Glossina palpalis*, the infective agent of sleeping-sickness. The occurrence, however, of cases of sleeping-sickness in circumstances where the agency of *G. palpalis* seems to be excluded, and the now well-known fact that there are several species of trypanosomes pathogenic to animals that can be carried by more than one species of *Glossina* are factors that make this easy-going view untenable even for the most unpractical of "practical" men. Moreover, according to Kleine the trypanosome of sleeping-sickness can develop to a certain extent in *Glossina morsitans*, and according to Koch *G. morsitans*, *G. pallidipes*, and *G.* "*fusca*" can all be artificially infected with this trypanosome.

In dealing with the species of *Glossina* and their distribution Mr E. E. Austen's *Handbook of the Tsetse-flies*, printed by order of the trustees of the British Museum, 1911, is here followed, in genuine appreciation of its merits.

Mr Austen, using characters which are *common to both sexes*, arranges the species of *Glossina* in four groups as follows:—

Synopsis of Groups of Glossina, *summarised from Austen.*

1.	All the segments of the tarsus of the hind legs are either entirely or in most of their extent dark	*G. palpalis group.*
	Only the last 2 segments of the tarsus of the hind legs are conspicuously darker than the other 3 segments	= 2.
2.	Upper surface of abdomen distinctly cross-banded	*G. morsitans group.*
	Upper surface of abdomen not distinctly banded	= 3.
3.	Wings fairly dark; palpi (except in *G. tabaniformis*) long and slender	*G. fusca group.*
	Wings pale; palpi short	*G. brevipalpis group.*

(a) *Synopsis of the Species of the* Glossina palpalis *Group.*

1. Upper surface of abdomen buff, with very distinct sharply defined dark brown cross-bands, broadly interrupted in the middle line, on the 3rd and following segments; on the 2nd segment the cross-bands are reduced to a large dark spot on either side. In the tarsus of the hind legs the extreme tips of the first 3 segments and the extreme bases of the 2nd and 3rd segments may be pale. Size small, the female being less—commonly very much less—than 8·5 mm., and the male being still smaller *G. tachinoides.*
2. Upper surface of abdomen dark brown, usually with a distinct appearance of *fine* cross-banding due to the fact that the *extreme* hind margins of the 2nd to the 6th segments are pale; a small pale triangular area on the 2nd segment continuous with a fine pale median line on the other segments. All the tarsal segments of the hind legs entirely dark brown above. Third antennal segment dark, not fringed with *long* hair. Female always more—commonly very much more—than 8·5 mm. *G. palpalis.*
3. Upper surface of abdomen dark brown, without any appearance of cross-banding. All the tarsal segments of the hind legs entirely dark brown above. In size approaching *G. palpalis* = 3.

3. { Third antennal segment pale, clothed with *long* fine hair which forms a *wide* fringe to its anterior and posterior margins *G. pallicera.*
Third antennal segment not pale and not fringed with *long* hair *G. caliginea.*

In the males of the *G. palpalis* group, as Newstead has shown, the large claspers are more or less claw-like in form and are connected by a membranous curtain.

(b) *Synopsis of the Species of the* Glossina morsitans *Group: after Austen.*

Last 2 segments of tarsus of front and middle legs with sharply defined clove-brown or black tips = 2.

Last 2 segments of tarsus of front and middle legs either entirely pale, or at most faintly brownish—never dark or black—distally *G. pallidipes.*

2. Third antennal segment with a distinct fringe of fine hair on front margin. Abdominal cross-bands extending close to the hind margins of the segments *G. longipalpis.*
Third antennal segment without a distinct anterior fringe of hair. Abdominal cross-bands not extending close to the hind margins of the segments *G. morsitans.*

In the males of the *G. morsitans* group, as Newstead has demonstrated, the large claspers are spatulate, and are connected with one another, not only by a membranous curtain but also by a phalange-like extension of their inner border.

(c) *Synopsis of the Species of the* Glossina fusca *Group:* after Austen.

1. Third segment of antennæ fringed with fine hair on anterior and posterior margins; fringe on anterior margin conspicuous under a hand-lens magnifying 15 diam. (nominal) when head is viewed in profile = 2.
Third segment of antennæ with the fringe of fine hair on the anterior margin so short as to be scarcely noticeable under a hand-lens magnifying 15 diam. (nominal) when head is viewed in profile—the length of the longest hairs of the fringe not exceeding one-sixth the width of the segment. Palpi long and slender = 3.

2. Length of the longest hairs of the fringe in question equal to from one-fourth to one-third the width of the segment specified. Palpi of moderate length *G. tabaniformis.*
Length of the longest hairs of the fringe equal to from one-half to three-fourths the width of the segment. Palpi noticeably long and slender *G. nigrofusca.*

3. Pleura drab-grey or isabella-coloured. Hind coxæ buff or greyish buff *G. fusca.*
Pleura dark grey. Hind coxæ mouse-grey *G. fuscipleuris.*

In the males of the *G. fusca* group that Newstead has examined, the large claspers are more or less claw-like—sometimes with bicuspidate tips—and are not interconnected by a membrane.

The species of this and the following group are of larger size than those of either of the other groups; the smallest females are never less than 10 mm. in length and the largest sometimes exceed 13 mm.

(d) *Synopsis of the Species of the* Glossina brevipalpis *Group:* after Austen.

Dorsum of thorax with four sharply-defined, dark brown, more or less oval or elongate spots, arranged in a parallelogram, two in front and two behind the transverse suture. Proboscis-bulb with a sharply-defined brown or dark brown tip — *G. longipennis.*

Dorsum of thorax without such spots. Proboscis-bulb not brown or dark brown at tip — = 2.

2. Wings with upper thickened portion of anterior cross-vein much darker in colour than the adjacent veins, and thus standing out conspicuously against the rest of the wing — *G. brevipalpis.*

Wings with the part in question not much darker, and thus not standing out conspicuously—wings practically unicolorous — *G. medicorum.*

The males of this group, so far as they have been examined by Newstead, have claspers of the *G. fusca* type.

Glossina palpalis, Robineau-Desvoidy.

According to Austen this species occurs (in suitable natural stations) over the whole of western Tropical Africa, from the mouth of the Senegal (about lat. 16° N.), eastwards by southwards to the southern Bahr-el-Gazal (about lat. 8° N.), then southwards along the basins of the Nile and of lakes Victoria and Tanganyika, then westwards by southwards to Benguela (about lat. 13° S.). Within this range, suitable conditions being present, it is usually found between sea-level and 3000 feet, and has not, according to Bagshawe, been recorded at an altitude above 4000 feet.

These suitable conditions include shade of some sort, a shade-temperature of about 85° Fahr., and the proximity of water to provide a fairly humid atmosphere. Though shade is indispensable, the fly is not active after sunset or in cloudy weather; though a moist atmosphere is indispensable, a water-logged soil is obnoxious, since the pupa has been shown, by Bagshawe, to require a light well-drained crumbling soil for its development; and though the propinquity of water is essential, the fly is known to follow travellers, both by road and rail, for a considerable distance from its riverside haunts.

Glossina palpalis is said to feed on the blood of any kind of mammal, and also to attack birds, reptiles, amphibia, and even amphibious fishes like certain gobies.

As regards reproduction, Roubaud, from observation of captive flies, found that the first larva was dropped about three weeks after coupling, and that other larvæ followed at intervals of nine or ten days. He also noticed that the larva transformed to a pupa in about three-quarters of an hour; that the pupal stage lasted, in suitable conditions, thirty-two to thirty-five days; and that pupæ were killed by prolonged burial in damp earth, or by several hours exposure to a hot sun even though covered with 2 inches of dry earth. Bagshawe observed that, in nature, pupæ of *G. palpalis* were to be found, more than an inch below the surface of the ground, in well-drained humus, sheltered by trees or bush, within 25 yards—commonly within 10 yards—of water; twice he found pupæ in crevices in rock, and twice between the buttress-roots of fig-trees. On the shores of Lake Victoria Nyanza, Marshall and Fraser found the pupæ in sand.

It is no part of our scheme to summarise the existing knowledge of this species as a pathogenic medium. It is sufficient to mention that whatever other species of *Glossina* may, in some particular locality, be hereafter shown to be implicated, *G. palpalis* is the species that the illustrious Bruce and his coadjutors first proved to "carry" the trypanosome of sleeping-sickness, and that is now believed, with good reason, to be the usual infective agent in spreading that appalling disease. Kleine followed with proof presumptive that the part played by the fly is not chiefly a mechanical

one, since a fly becoming polluted and dangerous by feeding on an infected animal very soon becomes innocuous, and after remaining innocuous for several weeks again becomes, and remains for several months, infective. Later, the exact experiments of Bruce and his staff, while corroborating Kleine, have brought numerous facts to light, among which the most important are (1) that only a very small percentage of flies experimentally fed on infected animals ultimately become infective; and (2) that the infectivity of this small percentage depends upon a delayed infection of their salivary glands. Bruce and his coadjutors have followed out the actual development of the trypanosome in the (small percentage of) infected flies that ultimately become infective; they have observed that the trypanosomes multiply most actively in the gut, but they have not yet succeeded in tracing their route to the salivary glands.

Prophylactic measures against *G. palpalis* are discussed by Bagshawe in the exhaustive account of the species published by him in the *Bulletin of the Sleeping-sickness Bureau* for January 1909. Since both the adult and the pupa are naturally found only in shade near the edge of water, he recommends the eradication of scrub and the free lopping (not necessarily felling) of large trees, for a distance of not less than 30 yards from the water's edge in infested places where natives congregate. It is the method of the prophets in dealing with the groves and high places of Baal and Ashtoreth. The eradicated scrub, etc., should be either removed or burnt on the spot, and the cleared ground should be stirred to expose any buried pupæ to the action of the weather and to the attacks of insectivorous birds. In support of this measure Bagshawe shows how deforestation in certain areas once infested has by the consequent desiccation of the soil incidentally led to the disappearance of the fly.

Bagshawe thinks that the collection of pupæ and the trapping of flies is like the labour of Sisyphus, son of Æolus; but elsewhere he mentions how a planter in the island of Principe caught large numbers of the flies by clothing natives in black cloth smeared with bird-lime. The proceeding is simple and direct, and is therefore *not* abundantly justified by any analogy, but it should certainly not be condemned

untried on any *a priori* grounds. The same remark applies to the use of ointments and lotions containing essential oils and insecticides; all these things should be tried where people can be induced to employ them, for there really seems no reason why men should not turn themselves into "natural enemies" of any aggressive insect by these passive means.

Certain zealots have recommended that the flies should be attacked, or at any rate disarmed, by the extermination of the wild animals upon which they feed, to their infection. This is the method of King Josiah in dealing with the abominations of Ashtoreth and Chemosh and Milcom, with a vengeance; and in the present state of our knowledge should certainly be discouraged by every medical officer as an idea beyond measure inhuman and impious. Of course if in this connexion sentence could with justice be pronounced against any particular species of animal that is itself directly dangerous to man (such as the crocodile), it could be executed without remorse.

Glossina palpalis var. *wellmani*, Austen.

This variety is, according to Austen, found in Angola, Gambia, the Katanga district of the Congo Free State, the Matondwi Islands of Lake Tanganyika, and elsewhere. It is said to be distinguishable from typical *G. palpalis* by a reduction of the longitudinal markings of the thorax (*cp.* Fig. 68), and to graduate into the typical form.

Glossina fuscipes, Newstead.

This supposed species is founded upon a single male specimen from the Nile Province of Uganda. It is said to be "readily distinguished from *G. palpalis* by its much smaller size, by the uniformly infuscated or dusky legs, and by the dusky-grey thorax."

Glossina maculata, Newstead.

This supposed species is founded upon a single female specimen, and is said to differ from *G. palpalis* in having the thorax, legs, and abdomen spotted. Messrs Austen and Waterhouse consider that the spots are adventitious.

Glossina caliginea, Austen.

This species is known at present only from Southern Nigeria. It differs from *G. palpalis* chiefly in its slightly larger size; in the abdomen being darker, though the pale area on the 2nd segment is larger; and in not having the hind margins of any of the abdominal segments definitely pale.

Glossina pallicera, Bigot.

This species, which has been found in places from Sierra Leone to French Congo, is said to be rare. It differs from *G. palpalis* chiefly in having the abdomen muddy brown without any pale definition of the hind margins of the segments, and in having the 3rd segment of the antennæ "cream buff to ochraceous buff," and fringed with long, fine, pale yellowish hair.

Glossina tachinoides, Westwood.

This is a small species, the length, according to Austen, being from 6·8 to 8·4 mm. in the female and from 6 to 6·75 mm. in the male. It has been found in West Africa, from Senegal to French Congo, in the French Sudan, in German East Africa, and in Southern Arabia, being the only species known to exist outside the African continent. It is easily recognised among the species having all the tarsi of the hind legs dark, by its small size, and by the very distinctly banded abdomen. The ground colour of the abdomen is buff, on the dorsum of the 2nd segment there are two lateral dark spots, and on the dorsum of segments 3 to 6 there are dark cross-bands which are broadly interrupted in the middle line, and fall considerably short of the lateral and hind margins of the segments.

Glossina morsitans, Westwood.

According to Austen, this, the original and notorious "tsetse-fly," is the most widely distributed of all the species of *Glossina*, its northern range being bounded on the west by Senegambia and on the east by Abyssinia, and its southern range extending into Zululand. Within these limits the fly is usually restricted to definite, more or less shady "belts,"

which are not always low-lying, the species having been taken, according to Austen, at an elevation of 5000 to 5500 feet. It has the abdomen banded almost as conspicuously as *G. tachinoides*, from which it is distinguished, *inter alia*, by its larger size and by having only the 2 terminal segments of the hind tarsi dark: from the two following species it is distinguished, *inter alia*, by the points emphasised in Austen's table.

G. morsitans is the living document of the famous discovery of Bruce and his colleagues, which proved this species—long suspected to be the "cause" of nagana, or tsetse-fly disease of domestic animals—to be a necessary medium for the maintenance of the species of trypanosome that is the true cause of that disease. *G. morsitans* has lately been brought under suspicion as a possible agent in the transmission of indigenous sleeping-sickness in an area (Nyassaland and North-east Rhodesia) where *G. palpalis* is believed to be non-existent. In this connexion it must be remembered that it has been demonstrated experimentally on the one hand that there are several species of trypanosomes that can be "nursed" by more than one species of blood-sucking insect, and on the other hand that there are several species of blood-sucking insects that can "nurse" more than one species of trypanosome.

Glossina submorsitans, Newstead.

Is said to differ from *G. morsitans* (1) in certain slight differences in the form of the claspers of the male; and (2) in having the dark abdominal cross-bands much more sharply defined, equally and more narrowly interrupted in the middle line on segments 3 to 5, and only slightly rounded, but abruptly sloping towards the lateral margins of the segments. Mr Austen regards it as a race of *G. morsitans*.

Glossina longipalpis, Wiedemann.

This, according to Austen, is essentially a West African species, but has also been found in the south-eastern corner of the Congo Free State. It is slightly larger than *G. morsitans*, has the dark abdominal cross-bands distinctly wider fore-and-aft, and has a conspicuous fringe of fine hair on the front margin of the 3rd segment of the antennæ.

Glossina pallidipes, Austen.

This, according to Austen, is essentially an East African species, its range extending from Zululand to (at least) the northern boundaries of Uganda and British East Africa. It resembles *G. longipalpis* at all points, except that the 2 terminal segments of the tarsi of the front and middle legs are either entirely pale, or may have faint traces of brown at their tips; whereas in *G. longipalpis*, as also in *G. morsitans* and its variety, the tips of the tarsi in question are conspicuously dark brown.

The seven following species are for the most part flies of conspicuously large size. Several of them were for some time confused with *G. fusca*, Walker.

Glossina fusca, Walker, Austen.

The range of the species, according to Austen, extends from Sierra Leone to the Uganda Protectorates, and is *not* known to include the East African Protectorate or German and Portuguese Africa, or Nyassaland or Rhodesia. Austen's measurements give the length of the male as 9·6 to 11·6 mm., and of the female 10·5 to 11·8 mm. The characteristic thoracic markings (*cp.* Fig. 68) are distinct; the abdomen is light dirty brown at base, becoming umber-brown distally, and there is no appearance of banding; the last 2 tarsal segments of the hind legs are dark brown, as are the tips of the same segments of the front and middle legs; the wings are dusky ("dull sepia-coloured"); the hairs of the arista number seventeen to twenty. *G. fusca* is said to bite at night, not uncommonly.

Glossina fuscipleuris, Austen.

Only one specimen is known, from the Eturi Forest in the north-eastern part of the Congo Free State. The species differs from *G. fusca* in having (1) the pleura "dark grey instead of drab grey"; (2) the coxæ of the hind legs "mouse-grey instead of buff or greyish-buff," and more conspicuously fringed on the lower part of the hind margin; (3) the fore end of the anterior cross-vein more conspicuously

thickened; and (4) the hypopygium of the male more nearly oval in outline.

Glossina nigrofusca, Newstead.

According to Austen, the range of this species extends at any rate from Ashanti to the Congo Free State. The species differs from *G. fusca*; (1) by having the 3rd segment of the antennæ clothed with long fine pale hair, which forms a conspicuous fringe to both borders of the segment, the width of the fringe on the anterior border being from one-half to three-fourths the breadth of the segment; and (2) in the greater number—twenty-two to twenty-eight or twenty-nine—of the hairs of the arista. It is said to enter houses.

Glossina tabaniformis, Westwood, Austen.

According to Austen, the area of distribution, so far as it is known, includes the Ivory and Gold Coasts, Southern Nigeria, and the Congo Free State. *G. tabaniformis* is believed to be found near houses and to board river-steamers, and to bite at night. It differs from *G. fusca* much in the same way that *G. nigrofusca* does, and differs from the latter species in having (1) the palpi and proboscis much shorter; (2) the fringe of hairs on the borders of the 3rd segment of the antennæ narrower, the longest hairs of the front margin being only from one-fourth to one-third the width of the segment; and (3) only eighteen to twenty-three hairs on the arista.

Glossina brevipalpis, Newstead.

According to Austen, this is the common *large* tsetse-fly of many parts of Southern, Central, and Eastern Africa, being found in Angola, the southern part of the Congo Free State, North-eastern Rhodesia, Nyassaland, and in Portuguese, German, and British East Africa. It is said to bite early in the morning and in the evening, and it has lately become suspect as a possible nurse of the trypanosome of sleeping-sickness in certain places where *G. palpalis* is believed not to exist. One of the most striking points of the species, to casual view, are the wings with the region of the anterior and posterior cross-veins so much darkened

("infuscated") as to look like two spots. It is distinguished from *G. fusca*, *inter alia*, by having (1) the proboscis and palpi much shorter; (2) the characteristic thoracic markings washed out in appearance; and (3) the wings paler. It is distinguished from *G. longipennis* by the points emphasised in Austen's table.

Glossina medicorum, Austen.

According to Austen, this species is known, at present, only from West Africa. It is the smallest of the *G. fusca* and *G. brevipalpis* groups, Austen's measurements being for the male 9 to 10 mm., and for the female 10 to 10·6 mm. It is said to present a superficial resemblance to *G. brevipalpis*, but to be distinguishable from that species by the uniformly pale wings.

Glossina longipennis, Corti.

An East African species, which, according to Austen, has up to the present time been recorded only from Somaliland and the East Africa Protectorate. It is said to be one of the most easily recognised of all the large tsetse-flies, by the four small dark brown spots on the dorsum of the thorax, and by the sharply defined dark-brown tip of the bulb of the proboscis.

Postscript.—Dr A. G. Bagshawe has just published the information (Sleeping Sickness Bureau, Bulletin No. 29, p. 291) that he has just learned through Dr Kleine that Dr Taute, on L. Tanganyika, "has successfully transmitted a human trypanosome to monkeys by means of *Glossina morsitans.*"

CHAPTER XII

Muscoidea (*continued*): The Minor Families of Muscoidea, and The Œstridæ

THE next four families — *Sarcophagidæ*, *Anthomyidæ*, *Tachinidæ*, and *Dexiidæ*—are here, in accordance with modern custom treated as distinct, but there are good authorities who still regard them merely as subfamilies of *Muscidæ*.

Family SARCOPHAGIDÆ: Flesh-flies (σάρξ = flesh; φαγεῖν = to eat). These flies, which have the habits of blow-flies, are distinguished from *Muscidæ* by having the distal half, or less, of the arista bare; the body also, though thick-set, is more elongate, and in most of the species the thorax is striped black and grey and the abdomen is checkered or mottled black and grey, though some of them have a bluish-black or metallic abdomen. Many of the *Sarcophagidæ* are viviparous, producing numerous small maggots at a birth.

The larvæ live in filth and carrion of all sorts, but some are parasitic in other insects, and the larvæ of *Sarcophaga* are not infrequently found in wounds and in the nasal passages, as well as in the intestine, of man. Cases have been reported, from several parts of the world, in which the frightful havoc wrought by *Sarcophaga* maggots burrowing from the nasal passages into the tissues of the head indiscriminately, has resulted in a painful and loathsome death, the fœtor being appalling. These larvæ much resemble Muscid larvæ (Fig. 53) in general form, and more particularly those of the screw-worm (*Chrysomyia*), the segments being separated by well-marked constrictions, but the spines that encircle the segments are minute.

Family ANTHOMYIDÆ (Fig. 69) (ἄνθος = a flower; μυῖα = a

fly). The flies of this large family can usually be distinguished from *Muscidæ*, which they resemble closely, by the course of the 4th longitudinal vein; it runs straight to the edge of the wing, rarely having any curve forwards, so that the 1st posterior cell is widely open. From the Acalyptrate Muscoidea, many of which have the same kind of wing-

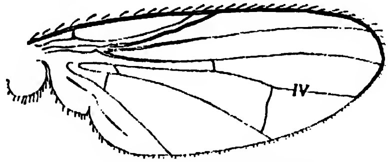

FIG. 69.—Wing of Anthomyid Fly.

venation, they can be distinguished by the large squamæ, and usually, in the male, by the eyes being approximated.

The eggs are commonly laid on plants, in which the larvæ are parasitic, and the larvæ thus do much damage in the market-garden. The larvæ of some species are parasitic in insects and other animals. Those of *Homolomyia canicularis* (a fly like a small house-fly, but easily distinguished by the straight course of the 4th longitudinal vein) sometimes find their way into the bowel, and even into the urinary

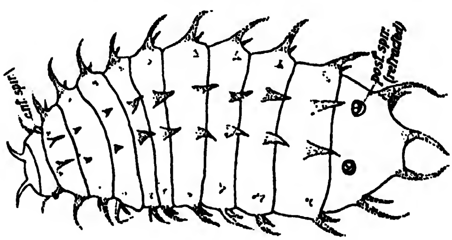

FIG. 70.—Larva of *Homolomyia*.

passages, of man. The curious maggot of this species is represented in Fig. 70.

The adults of a species of *Lispa*—a genus which is represented in many parts of the world—are said by Dr Atkinson to catch and ebibe mosquito-larvæ in Hongkong. *Lispa* can be recognised by its wide front, its very broad, spooned palpi, and its spotted abdomen.

Family TACHINIDÆ (ταχινά = ταχύς = swift). The flies of

this enormous family can usually be distinguished from *Muscidæ* by the bare arista and very bristly body. The larvæ live as parasites in the larvæ of other insects, particularly in the caterpillars of Lepidoptera, pupating in and ultimately destroying their victims. The tendency of the family is therefore beneficial, notwithstanding that certain species sometimes destroy the larvæ of useful insects. Some few *Tachinidæ* which have a long, pointed, chitinous proboscis, might be mistaken for blood-suckers.

Family DEXIIDÆ (δεξιός = nimble). The species of this very large family resemble *Tachinidæ* both in structure and habits. Like *Tachinidæ* they are very bristly, but usually the arista is pubescent and the body and legs are elongate.

Family ŒSTRIDÆ, Bot-flies. (Lat. *Œstrus* = οἶστρος = a fly that drives to frenzy). The adults of this family are very short-lived, and hence have the mouth small and the mouth-parts vestigial or rudimentary. They attach their eggs to the hairs of mammals, in which the resulting larvæ are parasitic—either in the stomach or intestine, or in the pharynx and nasal passages and the contiguous sinuses, or in the subcutaneous tissue. When the maggot is full grown it leaves its victim in order to undergo pupation in the ground. As a rule the larva of each species of fly has a preference for one particular species of mammal. A good many species are parasitic in domestic animals, and several of these may fortuitously victimise man; the species most known as a human parasite is the "Macaw-worm" (*Dermatobia noxialis*) of Tropical America.

The flies are more or less hairy and bee-like, and have a large head with a heavy, swollen, somewhat "underhung" face; the antennæ and the wing-venation are much like those of a Muscid fly, and the squamæ are usually large. The maggots are large and stout, and are ringed with many large, recurved, dark-coloured spines.

The four most common genera are the following:—

Gastrophilus. The larva lives in the stomach and intestine of the horse, ass, and some other Ruminants. In the adult fly the arista of the antennæ is bare, the squamæ are small, and the 4th longitudinal vein runs straight towards the edge of the wing, so that the 1st posterior cell is widely

open. The larva has two pairs of mouth-hooks—a small, straight, median pair, and a large, divaricated, lateral pair. The eggs are attached to the hairs of the destined victim, by whom they are probably licked off. The resulting larvæ attach themselves to the wall of the stomach or intestine by their mouth-hooks, their heads becoming at last fairly embedded in inflammatory pockets of the mucous membrane. When the larvæ are full grown they lose their hold, and are eventually passed with the droppings, whence they reach the ground, where they pupate.

Œstrus. The larva lives in the nasal passages and neighbouring sinuses of the sheep and some other Ruminants. In the adult fly the 4th longitudinal vein bends abruptly forwards so as to close completely the 1st posterior cell. The larva has a single pair of mouth-hooks; its ventral surface is flattened, and its dorsal surface is convex and

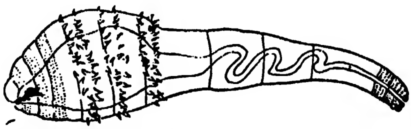

FIG. 71.—Macaw-worm; Larva of *Dermatobia.*

transversely wrinkled or tubercled. The eggs are laid on the victim's nose and the newly hatched maggots are said to creep up ths nostrils. When the maggot is full grown it drops or is sneezed out.

Hypoderma. The larva forms inflammatory tumours beneath the skin of various domestic animals. In the adult fly the 4th longitudinal vein bends forwards and there are no vestiges of maxillary palps. The larva has no mouth-hooks. The eggs are laid on the hairs of the victim, and it has been supposed that the newly hatched maggots bore through the skin; but Curtice gives reasons for believing that the eggs or young maggots are ingested by the victim and reach their destination under the skin by an internal route. When the maggot is full grown it pierces the skin and leaves its "host" in order to pupate.

Dermatobia. The larva is a subcutaneous parasite of various domestic animals and also, very commonly, of man,

in Tropical America and the West Indies, being known as the "Macaw-worm." It is—more particularly in its earlier stages—elongate pear-shaped (Fig. 71) or Indian-club shaped, the posterior part of the body being much attenuated. The broader anterior end is ringed with several rows of strong, black, recurved hooks.

CHAPTER XIII

Order Diptera (*concluded*): The Pupipara

(Lat. *Pupa*, and *pario* = to bring forth).

THE flies of this comparatively small group are so named because, so far as their method of reproduction is known, they give birth to a full-grown larva—one at a birth—which pupates almost immediately it is extruded; but as this

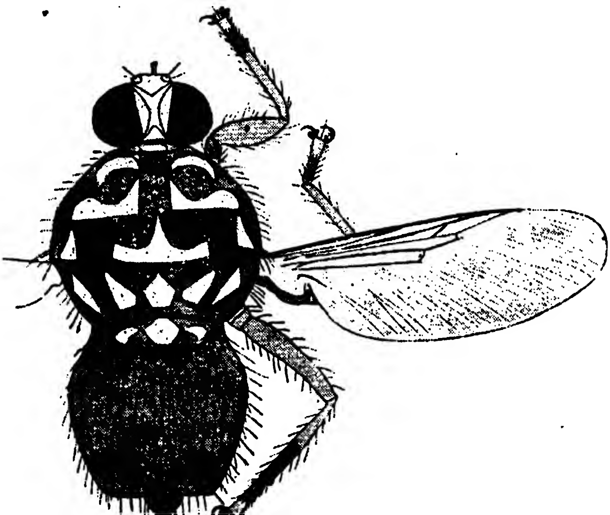

FIG. 72.—*Hippobosca maculata.*

method is now known to occur outside the group (in *Glossina*) the name as such is not exclusively appropriate.

The flies themselves are blood-sucking parasites which live concealed among the hairs of mammals and under the feathers of birds, but one minute species is a parasite of bees.

They are distinguished by the tough or strongly chitinised integument; by the head, which, as a rule, is either broadly impacted against, or turned right back on the thorax; by the broad thoracic sterna; by the often—though not always—indistinctly segmented abdomen; by the reduction of the antennæ; and by the stout legs—sometimes with the 1st tarsal segment elongate—ending in remarkably strong grasping claws, the heel of which is almost as sharp as the tip. The proboscis, which is retractile, is otherwise not unlike that of *Glossina*. Wings are sometimes present, sometimes vestigial, sometimes caducous, and sometimes altogether absent; when present their veins may be complete, or may be incomplete and a good deal crowded together in the antero-internal part of the wing. Though the *Pupipara* are blood-suckers they do not, except fortuitously, attack man.

The following families are included in this group:—

(1) *Hippoboscidæ* (Fig. 72). Head commonly flattened and broadly impacted against the thorax; legs strong but usually not remarkably elongate; wings well formed, or rudimentary, or absent; abdomen unsegmented. Parasitic on mammals and birds.

(2) *Streblidæ*. Head with a freely movable neck. Legs long, with the 5th tarsal segment usually enlarged. Wings present or absent. Abdomen imperfectly segmented. Parasitic on bats.

(3) *Nycteribiidæ* (Fig. 73). Long-legged, wingless, spider-like flies, with the head turned right back so as to repose upon the thorax, and with the 1st tarsal segment of the legs greatly elongate. Abdomen segmented. Parasitic on bats.

(4) *Braulidæ*. Consisting of a minute wingless parasite of bees.

In addition a small, unsegmented, headless insect, known as *Ascodipteron*, which was found buried in the skin of a bat in the Dutch East Indies, has been included among the *Pupipara*, as the type of a family *Ascodipteridæ*.

Family HIPPOBOSCIDÆ (ἵππος = horse; βοσκεῖν = to feed). The only family that need be further considered is that of the *Hippoboscidæ* (Fig. 72). In the *Hippoboscidæ*, or tick-flies, the head is sometimes globose and freely movable,

but is generally flattened and broadly impacted or sunk against the thorax. The antennæ are composed of a single segment, which is sunk in a pit on either side of the mouth, and bears a free bristle or a tuft of long hairs. The palpi are coarse and somewhat curved, and form a loose sheath for the proboscis when it is protruded. The proboscis, which is retractile, is much like that of *Glossina*, the labium consisting of a bulbous base and a slender shaft which forms a sheath for the acicular epipharynx and the filiform hypopharynx—these as in the Muscidea being the only mouth-parts, besides the palpi already mentioned, that are present. The thorax

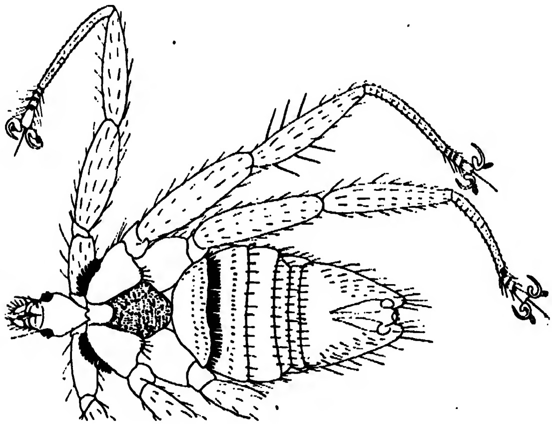

FIG. 73.—Nycteribiid Fly from "Flying-fox" Bat.

is flattened and strongly chitinised, its sterna being broad. The legs are, usually, not much elongated, but are stout and end in heavy and powerful claws; these have the heel almost as prominent as the tip, and sometimes have a third cusp near the heel. The wings in some species are well developed, and have a venation quite like that of the Muscidea; in other cases the veins are incomplete and are a good deal crowded in the antero-internal part of the wing; in other cases again they are narrow, or short and narrow (vestigial); in *Lipoptena* they are, as the name implies, caducous, and in the "sheep-tick" (*Melophagus*) they are entirely wanting. The abdomen is a tough sack with no distinct segmentation.

The *Hippoboscidæ* are to be regarded as *Muscidea* nicely

adapted to a parasitic life on mammals and birds, as is shown by the little use made of the wings—or the degeneration, or disappearance of these organs; by the great development of the legs, and particularly of the claws, for clinging; and by the method of reproduction, in which the safety of the larva is ensured by special means. They are found in all parts of the world, and though they do not habitually—or even commonly—bite man, they cause much annoyance to domestic animals; and certain species are known to be the infective agents of some destructive trypanosome diseases of domestic animals.

In some *Hippoboscidæ* the larva when extruded is known to pupate in the ground; but in *Melophagus* (the "sheep-tick") the pupa is often found entangled in the fleece of the parent's host.

Synopsis of genera of Hippoboscidæ; after Speiser.

A.	Wings well developed and functional	= 1.
B.	Wings rudimentary or wanting	= 2.
1.	Claws with the usual two points (heel and tip); parasitic on mammals	= 3.
	Claws with three teeth; parasitic on birds	= 4.
3.	Head of normal form, not broadly impinging on the thorax, freely movable; no ocelli. Wings always present	= *Hippobosca*.
	Head flat, broadly impinging on the thorax; ocelli present. Wings sometimes (in the female nearly always) becoming detached, leaving only a shred	*Lipoptena*.
4.	Ocelli present	= 5.
	Ocelli wanting. No anal cell	= 6.
5.	Anal cell present	= 7.
	No anal cell	= *Ornithophila*.
7.	Third longitudinal vein not elbowed at the anterior cross-vein	= *Ornithomyia*.
	Third longitudinal vein abruptly bent forwards at the level of the anterior cross-vein	= *Ornithœca*.
6.	Wings of a peculiarly pointed form, the tip however rounded	= *Lynchia*.
	Wings of the ordinary form but less expanded than in *Ornithomyia*, with broadly rounded tip	= *Olfersia*.
2.	Wings present, but rudimentary and functionless: halteres present	= 8.
	Wings and halteres absent	= *Melophagus*.
8.	Claws with the usual two points (heel and tip)	= 9.
	Claws with three teeth	= 10.

9. Ocelli present. Wings always well developed, but always in the female and generally in the male becoming detached, so that only shreds remain which resemble rudimentary wings = *Lipoptena.*
Ocelli wanting. Wings rudimentary. Legs much enlarged or elongated = *Allobosca.*

10. Ocelli present. Wings narrow, nearly ten times as long as broad, and longer than the abdomen = *Sternopteryx.*
Ocelli absent. Wings at most three times as long as broad = 11.

11. Wings as long as or longer than the abdomen = *Oxypterum.*
Wing-rudiments much shorter than the abdomen = 12.

12. Veins of the wings distinct. Asiatic species = *Myiophthiria.*
Veins of the wings indistinct. North American species = *Brachypteromyia.*

CHAPTER XIV

Order Siphonaptera (Aphaniptera): Fleas

Gr. σίφων = sucking tube; ἄπτερος = wingless; ἀφανής = invisible; πτερόν = wing.

THE Siphonaptera, or Fleas, are laterally compressed, wingless insects, with mouth-parts formed for piercing and sucking, and they undergo a complete metamorphosis in the course of their post-embryonic development. The head is broadly articulated to the thorax, and all three segments of the thorax are distinct and independent. Fleas have often been classed as a suborder of *Diptera*, but this arrangement can not be supported.

Fleas are active parasites of mammals and birds. Some fleas will suck blood from any warm-blooded animal indiscriminately, but the majority either restrict themselves to one definite species of animal (host), or have a decided preference for one species and attack other species with some reluctance. In one family (*Sarcopsyllidæ* or *Dermatophilidæ*) the females, besides sucking blood, eventually attach themselves to their host as fixed parasites, embedding themselves in its skin when they are pregnant.

Fleas may act as direct mechanical "carriers," and also as necessary intermediaries of other parasites of their host. Thus the common dog-flea, and the common European rat-flea are known to harbour the cysticercus of certain tapeworms of their respective hosts, and the trypanosome of the rat has been shown to pass through certain stages of its developmental cycle in the European rat-flea. But the great importance of fleas from the medical officer's standpoint is due to the part that these insects play as carriers of the plague-bacillus among rats and other rodents, and from these to man.

The flea about which most is known in this connexion is *Pulex* (*Xenopsylla*) *cheopis*, the species that most commonly infests house-rats in tropical latitudes; but it is reasonable to infer—and has, indeed, to some extent been demonstrated—that other species of fleas that attack the rat and other rodents may carry the plague bacillus. Thus it was shown in India that both *Pulex irritans* (the human flea) and *Ceratophyllus fasciatus* (the common rat-flea of temperate latitudes), and in California that *Hoplopsyllus anomalus* (a flea that infests the Californian Ground-squirrel and that also attacks the rat) are capable of carrying the bacillus.

As regards *Xenopsylla cheopis* it was conclusively proved by the Indian Plague Committee that this species is easily infected from infective rats, that the bacillus multiplies in its stomach so that it in turn becomes infective, and that it may remain infective for a term of fifteen days. The only point that remains obscure is the precise manner in which the contaminated flea passes on the infection. The experiments recorded by the Committee show at any rate that the bacillus does not pass into the body-cavity or into the salivary glands of the flea, but that the flea's fæces are infective, and the hypothesis most favoured is that the infected fæces of the flea somehow or other come in contact with the "bites" that the flea may subsequently inflict; and this hypothesis receives support from the well-known fact that in many insects that suck juices the act of sucking is accompanied with such violent peristalsis of the whole alimentary tract that the contents of the rectum are simultaneously ejected.

External Structure of the Flea.—The *head*, if small compared with the abdomen, is large in comparison with the thorax, and is irregularly conical in shape; the gena, or cheek, is wide, and its lower angle (genal angle) is often pronounced, or even produced backwards. An elegant comb of teeth is found in some fleas on the edge of the cheek, or on the lower edge of the head. Eyes may be present or not; when present they are simple (non-faceted). No supplementary ocelli are present. Behind and above the eyes are the antennæ, which in repose are lodged in definite grooves. Each antenna consists of 2 smaller basal segments, and a larger oval segment, or *club*, which is more or

less distinctly divided into nine rings. There are some definitely placed bristles on the head, the number and exact position of which are useful for discriminating species.

The most conspicuous appendages of the mouth are the maxillæ and their palps, which more or less conceal the other parts. The maxillæ are, commonly, triangular dependent flaps, and their stout segmented palps project like antennæ from the lower front of the head. Between the maxillary flaps are to be found the labial palps; these spring from an insignificant labial plate, are more or less segmented, and form by their apposition, a sheath for the piercing and suctorial tube. This last consists of (1) a pair of longitudinally grooved, finely serrated, needle-like mandibles, which by their apposition form an *efferent* tube for the passage of saliva; and (2) an unpaired bristle—the epipharynx—which by apposition with the mandibles, forms an *afferent* tube up which the blood of the victim is sucked.

The 3 segments of the *thorax* are quite independent. Each consists of a dorsal arc (tergum or notum) carrying one or more belts of bristles, and of two latero-ventral pieces ("sterna"). In some species the pronotum, or tergum of the 1st thoracic segment, has a comb of elegant teeth on its after edge.

The legs are composed of the usual segments, the number of tarsal segments being 5. All three pairs of legs are long and strong, the third pair being the longest. The legs are remarkable for the great length and breadth of the coxa; the femur also, and to a less extent the tibia, are usually much expanded. The number and disposition of the bristles of the several joints of the legs are used for distinguishing species. The paired claws are very strong, and have the heel extremely prominent.

The *abdomen*, which is large and deep, is composed of 10 segments, of which not more than 9 are plainly apparent. The first 7 are unmodified rings, consisting each of a tergal and sternal arc, bearing one or more belts of bristles; the last 3 are modified—differently in the two sexes—for sexual purposes. The 8th segment is much dilated ventrally, more so in the female. In the 9th segment the tergum is in great part occupied, dorsally, by a pitted and setose sensory plate

known as the *pygidium;* in the female the sternum of this segment forms the wall of the vagina; in the male the sides of the tergum form the large *claspers*, and the sternum forms a complicated mechanism for the support of the large and complex penis: all these sexually modified parts of the 9th segment, except the pygidium, are internal, though the tips of the claspers project externally. The small tergum and sternum of the 10th segment form in both sexes the roof and floor of the anus. The form of the claspers and penis of the male show characteristic differences in the different species, as do the number and disposition of the bristles on the sides of the 8th tergum of the female. A large bristle, or bristles, on either side of the 7th tergum project over and beyond the pygidium, and are known as *antepygidial bristles.*

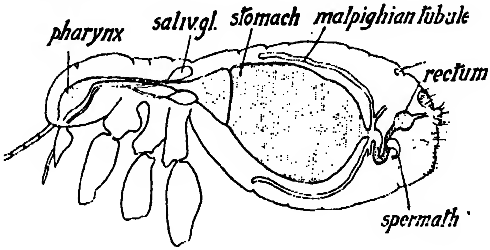

FIG. 74.—Alimentary Canal, etc., of Flea.

Alimentary Canal (Fig. 74).—In the head there is an elastic pharynx which works like a suction-pump, its cavity when expanded by the contraction of certain muscles, forming a vacuum. The gullet runs through the thorax, and expands in the abdomen into a large and very distensible stomach, the anterior end of which is muscular and valvular and is known as the "gizzard." A short curved intestine runs from the stomach to an enlarged rectum. At the junction of stomach and intestine there are four excretory Malpighian tubules. The salivary glands are two pairs; their common duct expands below the floor of the mouth to form a sort of contractile reservoir from which saliva is ejected down the salivary grooves of the mandibles when the flea "bites."

Reproduction and Metamorphosis.—The female flea is larger than the male and has a longer and more oval

abdomen. The curved *receptaculum seminis* is a conspicuous object in the female when the animal is mounted as a transparent object.

The eggs are large and are dropped by the female casually (*i.e.*, are not attached to the residential host of the parent). They fall to the ground and may be found in the places where domestic animals sleep. In summer the eggs hatch in two, three, or four days, but in winter the development within the egg may be prolonged to nearly a fortnight.

The larva (Fig. 75) is an active, footless maggot, of a whitish colour, and is sparsely but regularly hairy. It is composed of a head and 13 segments of nearly uniform diameter, the last segment ending in a pair of hooks. The head carries a pair of small antennæ, a pair of stout serrated jaws, and a pair of maxillæ with jointed palps.

FIG. 75.—Larva of Rat-flea (*Ceratophyllus*).

The larva eats the organic matter contained in the dust in which it lives, and in summer is full grown within a fortnight, though in winter growth is much delayed. When full grown the larva spins a cocoon, in which it pupates.

The cocoon is generally coated with adherent dust, and the pupa inside it is a small humpbacked creature faintly resembling the adult. The duration of the pupal stage depends upon the temperature, the usual term in warm weather being about a fortnight.

Classification.—The number of species of fleas already known is considerable. Mr C. F. Baker, in his incomplete revision of the order, gives a list of 135 species, and expresses the opinion that many hundreds of species will eventually be found. Our only concern here is with the limited number that have been found upon the rats and mice that frequent human dwellings, and with those few that attack man. These belong to two families, the *Pulicidæ* and the *Sarcopsyllidæ*.

In the *Pulicidæ*, of which the common human flea (*Pulex irritans*) may stand as a type, the thoracic segments are not foreshortened, the coxæ and femora of all the legs are much dilated, the head is more or less conical, and the *labial* palps consist of more than 3 segments.

In the *Sarcopsyllidæ*, of which the jigger (*Sarcopsylla* or *Dermatophilus penetrans*) may be taken as a type, the thoracic segments are much foreshortened, as if "telescoped," the coxæ and femora of the hind legs are only slightly dilated, the head is angulated, and the labial palps, which are feebly chitinised, consist of less than 3 segments, or even appear to be unsegmented.

For the determination of genera and identification of species, specimens should be dehydrated in spirit, cleared in oil of cloves, or xylol, or turpentine, and mounted in Canada balsam. In the case of large specimens it will be necessary first of all to soften them in caustic potash solution, and perhaps also to bleach them slightly in peroxide of hydrogen.

Family PULICIDÆ.

The following is a synopsis of the necessary genera:—

1. Eyes well developed (comb on head and pronotum absent or present) = 2.
   Eyes absent or vestigial (comb, or teeth, on head and pronotum always present) = 6.

2. No comb on head or pronotum = 3.
   A comb on pronotum only = 4.
   A comb on pronotum and two teeth on cheek, at the genal angle = *Chiastopsylla*.
   A comb on pronotum and on lower edge of head = *Ctenocephalus*.

3. Sternum of mesothorax divided by an internal chitinous thickening which runs obliquely forward from the coxal articulation = *Pulex*.
   Sternum of mesothorax divided by two internal chitinous thickenings, one as in *Pulex*, the other running vertically upwards from the coxal articulation to the upper border of the mesosternum = *Xenopsylla*.

4. Pygidium not freely projecting = 5.
   Pygidium strongly convex and freely projecting behind = *Pygiopsylla*.

5. Club of antenna incompletely segmented; only one antepygidial bristle on each side = *Hoplopsyllus*.
Club of antenna completely segmented; more than one antepygidial bristle on each side = *Ceratophyllus*.

6. None of the abdominal terga with combs = 7.
One or more of the abdominal terga with a comb = *Hystricopsylla*.

7. Bristles of hind border of tibiæ not in a close-set row = 8.
Bristles of hind border of tibiæ in a close-set row = *Ctenopsylla*.

8. Last tarsal segment of first and second legs with five *lateral* bristles on either side, of third legs with four = *Neopsylla*.
Last tarsal segment of first and second legs with four lateral bristles, of third legs with three = *Ctenophthalmus*.

Genus *Pulex*, L. (Fig. 76). In this genus there are no combs on head and pronotum, the eyes are large, and there

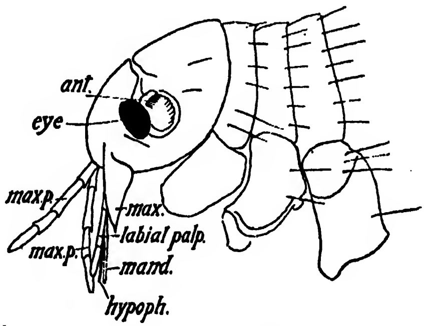

FIG 76.—Common Flea (*Pulex irritans*).

is only one pair of antepygidial bristles. The best known species is the human flea, *P. irritans*, L., which is as cosmopolitan as its host, and also attacks other animals, including the rat. Its principal specific characters are as follows:—there is no transverse row of bristles on the head, each abdominal tergum has only one belt of bristles, the labial palps are long and are composed of 3 segments, and there are numerous teeth in an irregular row on the inner side of the hind coxa.

Genus *Xenopsylla*, Glink. (Fig. 77). This genus differs very slightly from *Pulex*, the chief distinction being the presence of an internal chitinous thickening that runs from the coxal articulation of the second leg upwards through the

mesosternum to the uppermost corner of the latter. The most notorious species is *Xenopsylla cheopis*, Rothschild, the common rat-flea of the tropics.

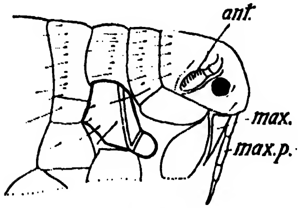

FIG. 77.—*Xenopsylla cheopis.*

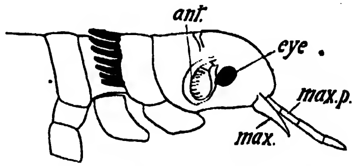

FIG. 78.—*Hoplopsyllus anomalus.*

Genus *Hoplopsyllus*, Baker (Fig. 78). This North-American genus is distinguished from *Pulex* by the presence of a comb of teeth on the hind edge of the pronotum. One species, *H. anomalus*, Baker, has been found on the rat; it is distinguished by having about nine teeth in its pronotal comb.

Genus *Ctenocephalus*, Kolenati (Fig. 79). The common cat and dog fleas, which are also found on rats and attack man, are the best known species. The teeth of the head-comb in these species are in a longitudinal row on the lower edge of the head. They are cosmopolitan.

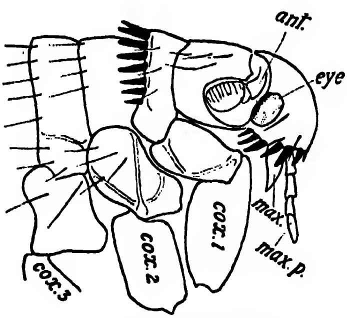

FIG. 79.—*Ctenocephalus.*

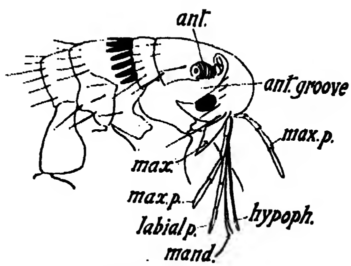

FIG. 80.—*Ceratophyllus.*

Genus *Ceratophyllus*, Curtis (Fig. 80). This is a very large and widespread genus. There is a comb on the pronotum, but not on the head, and there are three ante-pygidial bristles on each side. *C. fasciatus*, Bosc, a flea commonly found on rats in Europe, has eighteen to twenty teeth in the pronotal comb.

Genus *Pygiopsylla*, Rothschild. Two species of this genus are recorded by Rothschild from rats, and both are said to be common in Australia. The genus is characterised by its peculiar convex pygidium, the posterior edge of which projects free.

Genus *Chiastopsylla*, Rothschild. Distinguished from *Ceratophyllus* by having two teeth at the angle of the head behind the maxilla. Rothschild mentions one species from a rat from South Africa.

Genus *Ctenophthalmus*, Kolenati (Fig. 81). The eyes are vestiges, and there is a comb on the lower edge of the head and also on the pronotum: there are three antipygidial bristles on either side. *C. agyrtes*, found on the brown rat in Europe, has sixteen teeth in the pronotal comb, and three in the genal (head) comb. Other species have been found in America and South Africa.

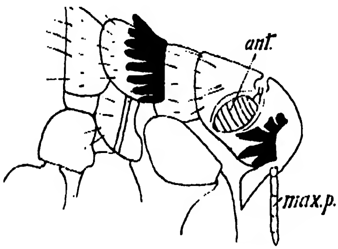

FIG. 81.—*Ctenophthalmus*.

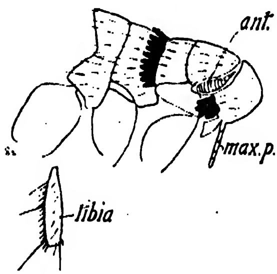

FIG. 82.—*Ctenopsylla*.

Genus *Neopsylla*, Wagner. One species, having two teeth at the genal angle, has been taken from a rat in Russia.

Genus *Ctenopsylla*, Kolenati (Fig. 82). The species are readily distinguished by the close-set, almost comb-like, row of bristles on the hind edge of the tibiæ. The head is sharply conical and has a comb, as has also the pronotum. *C. musculi* is of common occurrence on rats and mice in many parts of the world.

Genus *Hystricopsylla*, Taschenberg. The species of this genus are large and hairy: the head is conical, eyes are absent or vestigial, and some of the abdominal terga, as well as the cheek and pronotum, have a comb of teeth: the bristles of the posterior edge of the tibia are set in numerous close, transverse rows—three or four bristles in each row. In

H. pectinata, which occurs on mice and rats, there is only one abdominal comb, situated on the 1st tergum.

Family SARCOPSYLLIDÆ (Dermatophilidæ).

The following are the necessary genera :—

1. Hind coxa without a patch of spines on the inner side = *Dermatophilus* (*Sarcopsylla*).
2. Hind coxa with a patch of spines on the inner side = *Echidnophaga*.

Genus *Dermatophilus*, Guérin (*Sarcopsylla*, Westwood). The two recognised species of this genus are known as jiggers

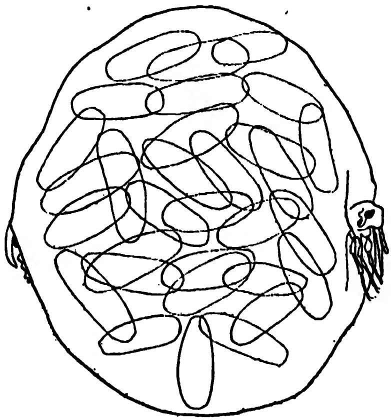

FIG. 83.—Pregnant female of *Dermatophilus penetrans*.

and both are indigenous to South America. The male is small, as is the female when not pregnant, and both sexes suck blood. But the female also attaches herself to her host, embedding herself in its skin in a sort of inflammatory pocket from which the tip of the abdomen protrudes for the extrusion of the eggs. When in this condition (Fig. 83) the abdomen of the gravid female swells to the size of a pea and loses its indications of segmentation, but at the poles (when the animal is removed and examined with a lens) the minute head and thorax and the tip of the abdomen can, in the species that attacks man, though not in the species that occurs on rats, be seen projecting.

The human jigger (*Dermatophilus penetrans*), though an

indigene of South America, was many years ago carried to the Gold Coast, and has since spread to East Africa and become established. From Africa it has been transported to Bombay, but does not seem to have made good its footing there. It is not a specific parasite of man, but also attacks other animals, particularly the pig. Jiggers flourish best in dry sandy places. They usually attack the feet, especially the toe-joints, but merely because the foot is the most accessible part. The presence of the pregnant swollen female naturally causes pain and inflammation, which may lead to indolent ulceration, and even to gangrene and to loss of a toe.

Genus *Echidnophaga*, Olliff (Fig. 84). This is a genus widely distributed in the warmer parts of the world. The

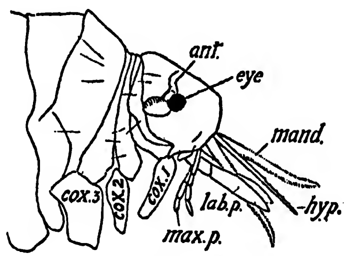

FIG. 84.—*Echidnophaga.*

best known species, *E. gallinacea*, is found on fowls and on many domestic animals. Several species attack rats.

Destruction of Fleas.—In the tropics, especially at the beginning of the hottest season, fleas are often a fearful pest, more particularly in rooms that have been left unoccupied for a short time. All doors and windows having been closed, the room may either be sprayed with a 5 *per cent.* solution of formalin, or copiously sprinkled with powdered naphthalin and then left *closed* for a day or two. Afterwards the room should be emptied, the mats be taken up and shaken on the spot, and the room be swept and the sweepings burnt to ensure the destruction of any eggs that may remain unaffected by the formalin or naphthalin. Before the mats are laid again the floor should be well washed with 5 per cent. formalin solution or 1 in 1000 solution of perchloride of mercury.

Prophylaxis against rat-fleas during an epidemic or epizoic of plague is part of the question of dealing with rats—a large sanitary question that cannot properly be considered in an entomological treatise. But it is appropriate to suggest that when an epizoic of bubonic plague is known to exist, ointments or oily applications containing some of the numerous substances known to be repellent to fleas (*e.g.*, quinine, quassia, sulphur, petroleum, turpentine, etc.), should be generally used by people who value their health and are not professed fatalists.

Ants, though in many ways a pest in a house, will help to rid it of fleas by devouring larvæ and pupæ.

CHAPTER XV

Order Rhynchota (Hemiptera): Bugs

(Gr. ῥύγχος = a snout or beak).

THE mouth-parts in the members of this large order, which includes true stinking bugs, cicadas, aphids, and scale-insects, form a very characteristic beak: two pairs of wings are typically present (though, as in most Orders, wingless species exist) and they may both be membranous, or the front pair may have the basal half thickened and hardened to form a wing-sheath. The metamorphosis is usually "incomplete," but in the case of the males of the scale-insects, is "complete."

The Rhynchota live by sucking juices; the majority of them live upon the sap of plants, and are responsible for an enormous amount of damage to crops of all kinds, but some prefer the juices of animals, and among these are certain species that suck the blood of man. It is chiefly these last that give the Order an interest for the medical officer; but he should also take heed of certain useful bugs that destroy other insects, and particularly of those predaceous aquatic species that may be reckoned as possible enemies of mosquitoes and their larvæ; nor must certain bugs that furnish useful products be forgotten.

The mouth-parts are quite characteristic. The *labium*, or "beak" (Fig. 85) is a *segmented* proboscis, usually of considerable length, and in repose is bent under the head: it is devoid of palps, and it is so deeply channelled along its whole length as almost to form a tube. In this tube the other mouth-parts lie, so that the labium is, like that of Diptera, a protective sheath, though very commonly, as in certain Diptera, it is also used as a dagger. The *mandibles* and *maxillæ*—which latter have no palps, and are barbed

or burred near the tip—are long, pointed bristles, and it is with these that the bug usually sucks. The mandibles are longitudinally grooved along their opposed surfaces—the groove being "double-barrelled"—so that when they are apposed two tubes are formed, down one of which the saliva runs while the desired juice is sucked along the other. The maxillæ embrace and support the mandibles. The *labrum* is present, but is quite short.

All 3 thoracic segments are distinct, though the posterior segments are often more or less hidden by the hardened bases of the front wings. The prothorax is free, and the mesothorax is commonly produced behind to form a *scutellum*.

The abdomen is commonly flat, and its lateral margins are often produced to form a sort of thin shelf or *connexivum*.

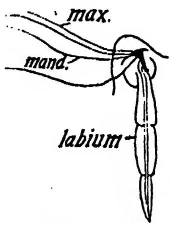

FIG. 85.—Mouth-parts of Bed-bug, dissociated.

The odour emitted by many bugs comes from the secretion of certain glands which, in the adult, open on the sternum of the last thoracic segment.

There are two distinct suborders of Rhynchota, namely, the *Heteroptera* (ἕτερος = diverse, and πτερόν = a wing), in which the front wings, when present, are hardened at base to form wing-covers or *elytra*, and the beak is merely reflexed; and the *Homoptera* (ὁμός = one and the same, and πτερον), in which the wings, when present, are of one consistence, and the beak is so much bent under that it appears to spring from the posterior border of the head.

RHYNCHOTA HETEROPTERA.

This suborder includes the true bugs. The hardened basal part of the front wing is known as the elytrum

(ἔλυτρον = a sheath), and the distal half as the *membrane*. The elytrum (Fig. 86) is composed either of two lateral pieces—a smaller inner plate, or *clavus*, and a larger outer plate, or *corium*; or the tip of the corium may be separated as a third distinct plate, or *cuneus*; or the outer (costal) edge of the corium may form a fourth distinct plate, or *embolium*.

The *Heteroptera* consist of two groups, namely, the *Gymnocerata* (γυμνὸς = naked; κέρας = horn), in which the

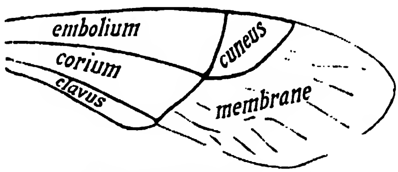

FIG. 86.—Elytrum of Bug.

antennæ are conspicuous; and the *Cryptocerata* (κρυπτός = hidden), in which the antennæ are hidden beneath the head or in pits. Except for certain forms that skate about on the surface of water, or that have semi-aquatic habits (and these forms are distinguished by having the under-surface of the abdomen covered with a dense pubescence), the Gymnocerata are land-bugs. The Cryptocerata are almost all truly aquatic.

(*a*) HETEROPTERA GYMNOCERATA.

Of the many families of GYMNOCERATA we need mention only the *Cimicidæ*, the *Polyctenidæ*, the *Reduviidæ*, the *Aradidæ*, and the *Hydrometridæ*.

1. Family CIMICIDÆ. This small family includes the bed-bugs. The Cimicidæ have a broad and rather short head, a flat oval body, and short elytra that leave the abdomen uncovered: the antenna is composed of 4 segments, and the beak, which in repose lies in a groove, of 3: hind wings are absent, and the tarsi consist of 3 segments.

The two notorious species are *Cimex lectularius*, the common bed-bug of northern latitudes, and *Cimex rotundatus* the bed-bug of the tropics.

CIMEX LECTULARIUS, L.

The insect, which is of a reddish-brown colour, is about one-fifth of an inch long, or rather less. The outline of its broad head is shaped something like a crown, the eyes projecting strongly. The 2 distal segments of the antennæ are much slenderer than the 2 basal segments. The beak (*cf.* Fig. 86) forms a stout three-jointed sheath for the bristle-like mandibles and maxillæ. The prothorax (Fig. 87) is large, its lateral margins are thin, and its

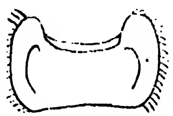

FIG. 87.—Pronotum of *C. lectularius*.

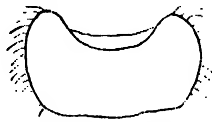

FIG. 88.—Pronotum of *C. rotundatus*.

anterior angles form two broad lobes on either side of the head. The broad elytra are beset with hairs, each hair springing from a pit. The abdomen consists of 8 segments; in the female it ends in a short, blunt lobe (Fig. 89); in the

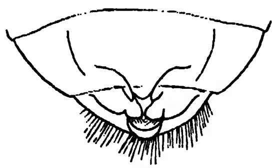

FIG. 89.—Tip of Abdomen of Bed-bug.

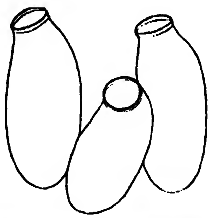

FIG. 90.—Hatched Eggs of Bed-bug.

male it also ends bluntly, and between the 7th and 8th segments the large, curved penis (*cf.* Fig. 91) is ensheathed.

The habits of the bed-bug are well enough known; during the day the insect hides in any kind of crevice, and at night it comes forth "the very blood to suck," like ancient Pistol. Bed-bugs do not appear to have any close breeding-season, except that they refrain in very cold weather.

The eggs (Fig. 90) are white and oval, and they cohere in clumps: each has a lid, which is pushed off when the larva emerges. The new-hatched larva is small and of a transparent whitish colour; it resembles the parent, but

has no trace of elytra, and the angles of the pronotum are not produced.

A mass of tradition and an extensive literature, have accumulated round the common bed-bug. It is commonly supposed to live for a year or more in unoccupied houses, some think without any food at all, though others suppose that it may get a chance meal off a mouse, or even off some dead animal. Recent experiments, by A. A. Girault, confirm the ancient tradition of the bug's vitality and endurance, and show that a bug can live at least 259 days (in cold weather) without food. The same writer observed that both larvæ and adults will feed off a mouse living or a mouse dead.

The bed-bug has been accused of carrying the infection of tubercle, leprosy, anthrax, plague, relapsing fever, and typhus fever; the assumption is likely enough, but actual proofs are still wanting.

Girault's observations show that a bed-bug starting in a state of repletion, and afterwards fed periodically, laid 111 eggs during a term of sixty-three days, and died eighteen days after depositing the last egg; and that another replete bug, not afterwards fed, laid only 7 eggs in a term of ten days, and died fifteen days afterwards.

The same observer, following the career of an individual larva, found that it fed immediately after hatching, and then fed again three times before moulting on the thirteenth day; thereafter it moulted four times, at successive intervals of nine, thirteen, four, and nine days, filling itself to repletion once between each moult, and became adult on the forty-eighth day of its life. He also states that certain imprisoned larvæ kept without food lived, some thirty-nine days, others sixty-five days. The rate of development, both embryonic and post-embryonic, is profoundly affected by temperature, being as usual retarded by cold.

Extermination of Bugs.—It must be remembered that any number of bugs may pack themselves away in inaccessible places—behind wainscoting, between floor-boards, in cracks in walls, etc. It must also be remembered that bugs and larvæ may be killed by treatment which does not affect the more resistant eggs. A badly infested room may first be

thoroughly fumigated with sulphur in the way recommended for *Dermestes*, plenty of sulphur being left to burn itself out after the room has been "hermetically sealed." The following day the room may be opened and it and all its contents well cleaned with some fluid that suits the case—*e.g.*, 5 per cent. solution of formalin, 3 per cent. solution of crude petroleum in water, 1 in 1000 watery solution of perchloride of mercury if there is no metal to spoil; or crude creasote, crude carbolic acid, turpentine, benzine, or acetic acid may be used. The disinfectant should be applied freely with a garden squirt so as to reach the depths of all crevices.

Cimex rotundatus, Signoret (Fig. 91), the bug of warm countries, much resembles *C. lectularius*, but can be distin-

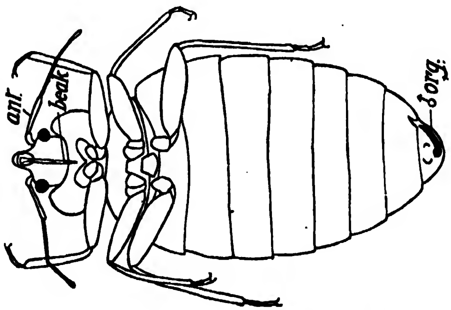

FIG. 91.—*Cimex rotundatus*, ventral view, male.

guished by the more elongate and more narrowly oval abdomen, and by the greater dorsal convexity of the pronotum. The pronotum (Fig. 88) has much the same outline, but its margins are not so thin. According to Patton this species is the intermediary host of the piroplasma of kála-azár.

Cimex macrocephalus, Fieber. From Burma, seems to be identical with *C. rotundatus*.

Cimex columbarius, Jenyns, is found in pigeon-houses but will attack man. It differs from *C. lectularius* in being smaller; in having the abdomen circular and merely subacute at tip; in having shorter antennæ, with the segments not quite so slender, and the difference in length between the 3rd and 4th segments not so considerable; and in

having the thorax less emarginate in front, less produced at the anterior angles, and less reflexed at the sides.

Cimex hirundinis, Jenyns, is found in the nests of the house-martin. It is more pubescent than *C. lectularius;* the abdomen is narrower, and more rounded at the tip; the antennæ are comparatively short; the thorax is much less emarginate in front, and has its anterior angles but little produced, and its sides hardly at all reflexed.

Cimex pipistrelli, Jenyns, is found on certain bats. It is very pubescent, almost hispid; the abdomen is more attenuated posteriorly; the sides of the thorax are little reflexed; and the femora are more swollen.

2. Family POLYCTENIDÆ. Small wingless bugs (short elytra are present) found on certain bats in South America. They are not unlike bed-bugs, but have a narrower abdomen, and 4 segments in the tarsi.

3. Family REDUVIIDÆ. A very large family of active, rapacious land-bugs, found in all parts of the world, and particularly numerous in the tropics. The head is usually elongate; the antennæ are long, and consist of 4 segments; the eyes are placed well forward, with the ocelli, when present, well in rear of them; the beak usually consists of 3 segments, is not very long, and is merely bent under the head, not closely applied to the under-surface of the head, in repose; the elytra when present, have no cuneus; the scutellum is comparatively short; and the legs are long with a tarsus of 3 segments. In one subfamily, the *Nabidinæ*, the front legs are raptorial, much like those of a Mantis. Several species of *Reduviidæ* are found in houses and attack man at night; the most notorious of them belong to the genus *Conorhinus* (Fig. 92).

Among *Reduviidæ* the genus *Conorhinus* is distinguished by the following combination of characters:—The head is long, the 1st segment of the beak is very much shorter than the 2nd, the antennæ are inserted about midway between the eyes and the tip of the snout, the ocelli are placed far apart, the prosternum is broadly grooved, and the posterior tibiæ are longer than their femora. The species of Conorhinus are found in North and South America, the West Indies, West Africa, Madagascar, throughout the Oriental Region, and in China.

Conorhinus infestans is a well-known blood-sucker in South America; it is spoken of by Darwin as "the great black bug of the pampas." *Conorhinus sanguisuga* is another nocturnal blood-sucker in America: it is coloured dark brown with reddish markings.

Conorhinus megistus, Burm., is a large black species, with numerous regularly arranged red markings, and is common in huts in certain parts of Brazil, where it is known as "Barbeiro." It is not merely a voracious nocturnal blood-sucker, but has also also been found by Chagas to interpose in the developmental cycle of a trypanosome (*T. cruzii*) which is parasitic in the blood of human beings and produces symptoms which somewhat resemble those of kála-azár and

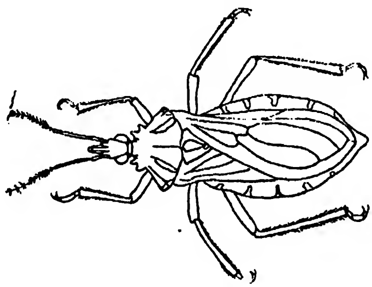

Fig. 92.—*Conorhinus.*

pellagra combined. The trypanosomes are said to be injected into man with the saliva of the bug when the insect bites. Reaching the capillaries of the lungs they are said there to become quiescent and to multiply by schizogony. The resulting merozoites pass from the lungs into the general circulation, where they are said to lodge and grow in the red blood cells, destroying these, and at last becoming free trypanosomes in the blood-plasma. In the bug it is said that the imbibed trypanosomes, after becoming pear-shaped, multiply by fission in the stomach; that the pear-shaped products of fission become Crithidiform, and then again multiply by fission in the intestine; and that the Crithidia forms, having acquired the undulating membrane, are ultimately found as trypanosomes in the body-cavity and salivary glands.

A nocturnal species that is sometimes found in houses in

India and is known to "bite" man, is *Conorhinus rubrofasciatus*, De Geer, which hardly differs from *C. megistus*, being of a dull dark-brown colour, with the markings on the pronotum, elytra, and connexivum dusky yellow, or brick-red. It has been suggested by Donovan that *Conorhinus rubrofasciatus* is interposed in the developmental cycle of the kála-azár piroplasma. According to Distant this bug has a very wide range, being found in India and the whole Oriental Region.

Among the Reduviidæ known to attack man in Africa is *Phonergates bicoloripes*, which also has once been observed—the incident is recorded by Austen—to seize and feed upon an *Ornithrodorus moubata*—the tick that carries the spirillum of African relapsing fever. It is not known, however, whether this is a habit; and even if it be a habit the issue of it, so far as any possible benefit to man is concerned, may be considered doubtful. Some small species of *Reduviidæ* have large transparent wings and rather resemble gnats; among them is one Asiatic species that attacks man.

4. Family ARADIDÆ. The bugs of this family are broad and more than ordinary flat; the connexivum is very broad

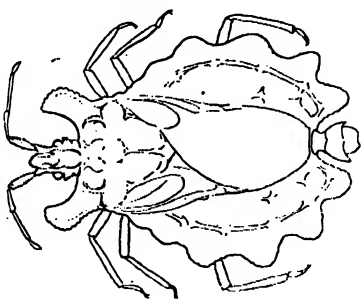

FIG. 93.—"Pito" Bug (*Dysodius lunatus*).

and thin; the antenna consists of 4 segments, and the beak of 3; the scutellum is comparatively short, and the elytra have no cuneus; the legs are of the ordinary form, and the tarsi are composed of 2 segments. The *Aradidæ* are found in most parts of the world living under bark and lichen, etc. One large South American species, *Dysodius lunatus*, Fabr. (Fig. 93), known in the vernacular as the "Pito" bug, is said to frequent houses and to bite severely. Certain other plant

bugs belonging to other families are also known to bite man occasionally.

5. Family HYDROMETRIDÆ: Pond-skaters, or Water-striders. The bugs of this family skim about on the surface of water, often in companies, and usually have very long legs. They prey upon aquatic insects, etc., and may be regarded as potential enemies of mosquitoes and mosquito-larvæ. The species of *Halobates* live on the surface of the ocean, often many hundreds of miles from land.

(*b*) HETEROPTERA CRYPTOCERATA.

The true water-bugs with concealed antennæ are all predaceous, and may possibly include mosquitoes and mosquito-larvæ in their prey; moreover, some of them when handled can give a very shrewd "bite," that of the giant water-bug (*Belostoma*) being well known in India as envenomed. The following are the several families:—

(1) *Galgulidæ;* squat toad-shaped bugs, with prominent eyes, that frequent marshy places in most parts of the world: the legs are of the ordinary form for crawling. (2) *Naucoridæ;* flat, oval bugs which, though truly aquatic, have not the legs modified for swimming; they are distinguished from the Galgulidæ by (among other things) the absence of ocelli. (3) *Nepidæ*, or Water-scorpions, common in stagnant waters everywhere; the long front legs are raptorial and the abdomen ends in a long slender breathing-tube formed of two lateral separable pieces; in one genus, *Nepa*, the body is leaf-like, in the other genus, *Ranatra*, it is more like that of a stick-insect. (4) *Belostomatidæ*, Giant water-bugs, common in stagnant water in tropical and sub-tropical countries; the body is oval and flat and the legs are flattened for swimming; there is no breathing-tube at the end of the abdomen; some of the species are large enough to overpower frogs and fish; the "bite" of *Belostoma* is very painful. (5) *Notonectidæ*, or Water Boatmen; oval bugs with very long, feathered hind legs; they swim on their back. (6) *Corixidæ;* much like water boatmen, but they swim right way up, and have the beak concealed and apparently unsegmented, the beak of the water boatmen being free and consisting of 3 or 4 segments.

RHYNCHOTA HOMOPTERA.

This suborder, though it comprises a number of the worst pests of agriculture, is of no particular interest to the medical officer. It includes the Cicadas (*Cicadidæ*); the often brilliant-coloured and long-snouted, or bottle-nosed Lantern-flies (*Fulgoridæ*); the Frog-hoppers, or Spittle-insects (*Cercopidæ*), the larvæ of some of which live embedded in froth (frog-spit or cuckoo-spit); the Leaf-hoppers (*Jassidæ*), which resemble slender frog-hoppers; the grotesque, goblin-like Tree-hoppers (*Membracidæ*), with their large, sharply angulated, elevated, often cap-like pronotum; the Jumping Plant-lice (*Psyllidæ*), which resemble tiny cicadas; the Plant-lice, or "Blight" (*Aphidæ*); and the Scale-insects, or Bark-lice (*Coccidæ*).

The males of the scale-insects have only one pair of wings, the hind pair being represented by stalked hooklets somewhat resembling the halteres of Diptera; but they can be distinguished from any midge by their long caudal filaments, and entirely different (vestigial) mouth-parts.

Many lantern-flies and some aphids secrete wax, which is utilised in some countries; some aphids and coccids make plant-galls; manna is the secretion of a coccid; lac and lac-dye are products of an Indian coccid; the well-known cochineal is obtained from a coccid which originally came from Tropical America, but has been naturalised elsewhere by man.

Order THYSANOPTERA : Thrips

(Gr. θύσανος = a tassel, or fringe, and πτερόν = wing).

The minute insects known as *Thrips* (θρίψ = a wood-worm) are usually found on plants, very commonly in the flowers; some of them form galls. They are active, squirming little creatures, usually with four long, very narrow, almost feather-like wings, though some species are wingless. The mouth-parts consist of piercing mandibles ensheathed in a sort of beak formed by the labrum, maxillæ, and labium; with these they suck the juices of plants, and some of them do much damage to grass, garden-crops, and orchards. From the medical point of view these tiny insects are not, so far as is known, of any importance. They are placed here for convenience, merely because they have sometimes been associated with the Hemiptera.

CHAPTER XVI

Order Anoplura, or Siphunculata (Blood-sucking Lice)

THE lice, which some authors regard as a suborder of the Rhynchota, are small, flat, wingless, blood-sucking parasites of mammals, clinging to the hairs of their host by their powerful claws. There is no metamorphosis.

Lice much resemble *Mallophaga*, but can at once be distinguished from them, under the microscope, by the absence of mandibles. The species that are parasitic on man have been supposed, like the bed-bugs, to disseminate various pathogenic microbes—*e.g.* of tubercle, leprosy, typhus fever, plague, relapsing fever, etc.—and to pave the way for various infections of the skin. The trypanosome (*T. lewisi*) of the rat can undergo certain developmental stages in the rat-louse (*Hæmatopinus spinulosus*).

The head of the louse is small, and the antennæ, which consist of 3, 4, or 5 segments, are stumpy; the eyes, which are simple, are set far back. The mouth-parts consist of two tubes, one inside the other, both being completely retractile; the outer, ensheathing tube, which is supposed to be homologous with the labium of other insects, has its free edge armed with tiny hooklets, and is used for attachment to the skin of the host when the insect sucks; the inner, ensheathed tube, which is supposed to represent the united mandibles and maxillæ, is the sucking organ, and when in action is insinuated deep into the skin of the host. These tubes can only very rarely indeed be made out at all satisfactorily in the dead insect; in the specimen figured (Fig. 94) which was immersed in creosote when in a state of repletion, both tubes are just visible, being not completely retracted into the head.

The thorax is wider than the head, but rather narrower than the abdomen, the 3 component segments are not always easy to distinguish. There are no traces of wings. The legs are generally stout and coarse; the tarsus consists either of a single segment or of 2 indistinctly separated segments, and ends in a remarkable stout hook-like claw, which bites against a sort of "thumb" at the opposite angle of the tibia. In the legs of a louse of the elephant, however, the legs are long and slender, and the tarsus ends in two claws of unequal size.

The number of abdominal segments ranges from 6 to 9; in the female (Fig. 94) the last segment is bilobed; but in the male (Fig. 95) the abdomen ends bluntly, and the heavy

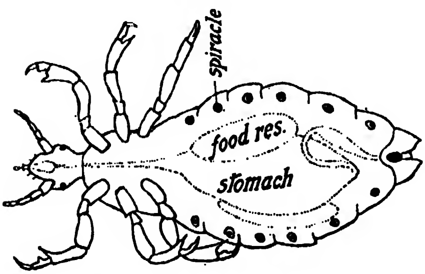

FIG. 94.—*Pediculus capitis*, female.

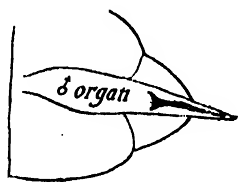

FIG. 95.—*P. capitis*, male.

spike-like penis projects beyond its tip. The spiracles are very prominent towards the sides of the segments.

The eggs, which are large and are known as "nits," are stuck to the hairs of the host (or it may be to the clothing in the case of man). The new-hatched young resemble the parent in everything but size.

Leeuwenhoek in the seventeenth century made some interesting observations on the breeding of the human body-louse (*Pediculus vestimenti*, Leach). He put two females in his stocking, which was tied so as to prevent their escape. Six days afterwards he found one of the insects with 50 eggs alongside, and another batch of 40 eggs probably laid by the other insect, which had escaped. On killing the insect that remained he found 50 more eggs in its body. He left the eggs in his stocking for another ten days, when he found 25 young lice, and then he abandoned his observations in disgust.

Warburton has recently followed out the life history of some individuals of the same species. An impregnated female, kept in a tube at the temperature of the body, and allowed to suck blood twice a day, produced 125 eggs in the course of twenty-five days (in the month of December) and then died. Of the eggs that were kept under observation, some hatched in eight days, others did not hatch for more than a month. The larvæ sucked blood immediately after hatching, and became adult in about eleven days, moulting three times during their growth; as adults they did not exercise sexual functions for four or five days after reaching maturity, and they died (they were males) three weeks after their final moult. Larvæ not allowed to suck blood died in thirty-six hours; and adults kept from blood died in three or four days. These experiments show that under suitable conditions lice increase in numbers with amazing rapidity, and that they cannot live long without blood as so many other blood-sucking Arthropods can.

The *Siphunculata* have recently been split up into families and subfamilies, but the older view that they form a single homogenous family—*Pediculidæ*—seems much more reasonable. The species are not very numerous, and only three of them are constantly parasitic on man.

Synopsis of Genera of Pediculidæ.

1.	Antennæ of 3 segments	= 2.
	Antennæ of 4 segments; integument spinose; on Seals	= 4.
	Antennæ of 5 segments	= 5.
2.	Eyes large and well pigmented	= *Pedicinus.*
	Eyes inconspicuous	= 3.
3.	Femur and tibia of hind legs with stalked platelets projecting outwards at a right angle	= *Euhæmatopinus.*
	Hind legs normal: lateral margins of abdomen serrated	= *Hæmatopinoides.*
4.	Abdominal segments with not more than three transverse rows of spines	= *Echinophthirius.*
	Abdominal segments with six to eight transverse rows of spines; dorsum with scales	= *Lepidopthirius.*
5.	Legs long and slender, tarsi with two unequal claws; head anteriorly tubular; on elephant	= *Hæmatomyzus.*
	Legs short and robust, tarsi ending in a single talon	= 6.
6.	Eyes large and well pigmented	= 7.
	Eyes inconspicuous or absent	= 8.

7. Abdomen broad; first pair of legs much slenderer than the others = *Phthirius*.
Abdomen elongate; all the legs equally robust = *Pediculus*.

8. Legs with a triangular pretarsal sclerite; all the legs equally robust; eyes vestigial; lateral margins of abdomen festooned; abdominal segments with a single transverse row of short hairs = *Hæmatopinus*.
Legs without pretarsal sclerite; the first pair more slender than the others; eyes absent = 9.

9. Abdominal segments well chitinised; lateral margins of abdomen festooned; hind legs stouter than middle legs = 10.
Abdomen soft, not festooned; hind legs not stouter = 11.

10. Abdomen with transverse rows of long stout hairs, most of the segments subdivided = *Polyplax*.
Abdomen with some rows of long, flat, scale-like hairs; sides of segments 3 to 6 produced dorsally and ventrally into a spur serrated at tip = *Hoplopleura*.

11. Abdominal segments with two or three transverse rows of long dense hairs; stigmata remarkably large; head tapering. = *Trichaulus*.
Abdominal segments with one transverse row of hairs = 12.

12. Abdomen elongate, its lateral margins smooth and unarmed; stigmata very small, not prominent = *Hæmodipsus*.
Abdomen broader, its lateral borders with a strong spine behind the stigmata, which are of moderate size and prominent = *Solenoptes*.

Genus *Pediculus*. Piaget admits three species, of which two, *P. capitis* Leach and *P. vestimenti* Leach, are human parasites.

Pediculus capitis is known as the head-louse, but though its favourite home is the scalp, it and its eggs are frequently found on other parts of the body and in the clothing. *Pediculus vestimenti* is the body-louse. The two species are difficult to distinguish. *P. capitis* is smaller; the abdomen consists of 7 segments, has its sides festooned, and is beset with hairs; the "thumb" of the tibiæ carries a spine. *P. vestimenti* is larger; the abdomen consists of 8 segments, is not deeply festooned at the sides, and is not hairy; the "thumb" does not always end in a spine. The "bite" of *P. vestimenti* is said to be very much more irritating than that of *P. capitis*. According to Andrew Murray, the different races of men have their corresponding races of *Pediculi*, the latter differing one from another, not merely

in colour, but also in the form and proportion of the tarsi and claws—especially those of the front legs—these grasping organs being nicely adapted to the calibre of the individual hairs of each particular race of man.

Genus *Phthirius*. One species is known, *Phthirius inguinalis*, Leach (Fig. 96), the "Crab" louse, which is particularly at home in the hairs of the pubis, though it is not restricted to that situation. It is distinguished from other lice by its broad squat body, and by the line of three spiracles on each side of the 2nd abdominal segment. The abdomen consists of 6 segments, and its sides are strongly

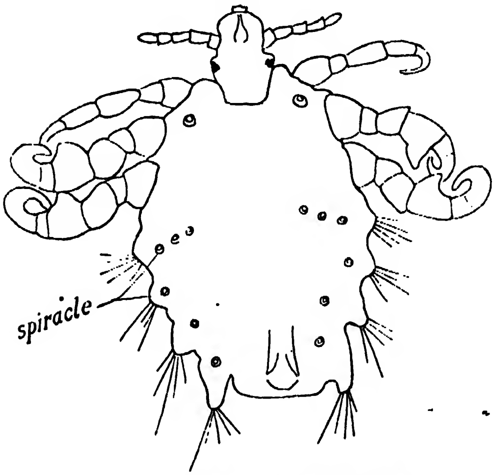

FIG. 96.—*Phthirius inguinalis*, male.

festooned. The first pair of legs are decidedly more slender than the others; in the second and third legs the claws are very massive and are bent like talons, and the thumb of the tibiæ is prominent. The species often goes by the name of "Pediculus pubis."

Other species of *Pediculidæ* may occasionally attack man.

In ordinary civil life lice are found only on dirty people; but the vicissitudes of travel or of arduous military service may occasionally bring even the most fastidious of us into contact with these despicable enemies of mankind. Soap and water and any of the familiar antiseptics will get rid of them; paraffin is efficacious in the absence of any pleasanter antidote. Clothing and bedding can be boiled or baked.

CHAPTER XVII

Order Mallophaga (Bird Lice, Gnawing Lice)

(Gr. μαλλός = wool, and φαγεῖν = to eat).

THIS is a small order of small wingless insects that inhabit the fur of mammals and the feathers of birds, which parts they gnaw and eat. No species is known to occur on man.

The order is closely related to the *Orthoptèra* (p. 245), and it must not be confused with the true blood-sucking lice (*Anoplura*), which are related to the bugs and have a suctorial proboscis.

The *Mallophaga* are flattened, wingless, louse-like insects that do not undergo metamorphosis. The head is large, the antennæ are short and occasionally concealed, the eyes are much reduced or are altogether

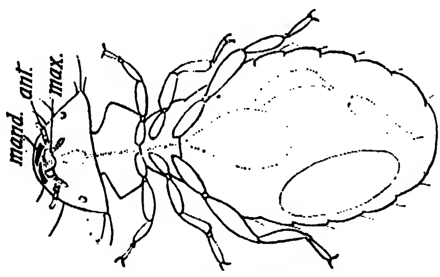

FIG. 97.—Fowl-louse, *Menopon*.

absent, and the mouth-parts are formed for biting It is not always easy to distinguish all the mouth-parts, but in specimens mounted for the microscope the dark-coloured hook-like mandibles are always visible, as also in some of the commonest species are the labial palps.

The prothorax is distinct, but the mesothorax and metathorax are often united, and are sometimes not clearly differentiated from the abdominal segments, which are from 8 to 10 in number. The tarsi are composed of 1 or 2, rarely of 3 segments, and terminate in either one or two claws. The eggs are supposed to be attached to the hairs and feathers of the host.

The Mallophaga are supposed not to do any harm to their hosts, but the species (Fig. 97) commonly found on the domestic fowl may often

be seen to be full of the fowl's blood, so that this supposition may be not quite correct. For this reason—although these insects are not known to trouble man—it is just as well that the medical officer should be able to distinguish the different genera. The following table of genera is taken from Kellogg (*Psyche*, 1896, p. 375).

SYNOPSIS OF MALLOPHAGA.

1. Antennæ filiform, with 3 or 5 segments; no labial palps — ISCHNOCERA.
2. Antennæ clavate or capitate, with 4 segments; labial palps 4-segmented — AMBLYCERA.

1. ISCHNOCERA.

a. Antennæ with 3 segments; tarsi with one claw; parasitic on mammals = *Trichodectidæ*, with one genus *Trichodectes*.

b. Antennæ with 5 segments; tarsi with two claws; parasitic on birds — *Philopteridæ*.

PHILOPTERIDÆ.

	Antennæ similar in both sexes	i.
	Antennæ differing in the two sexes	ii.
i.	Front deeply angularly notched	*Acidoproctus*.
	Front convex, truncate, rarely emarginate but never angularly notched	3.
3.	Elongate narrow species, with very small or no trabeculæ at the anterior angle of the antennal fossa	*Nirmus*.
	Broad short species, with large movable trabeculæ	4.
4.	Forehead with a broad transverse, membranous flap projecting beyond the lateral margin of the head in the male, barely projecting in the female	*Giebelia*.
	Forehead without such membranous flap	*Docophorus*.
ii.	Broad species, elongate-oval to suborbicular	5.
	Narrow elongate species with sides subparallel	vi.
5.	Temporal margins rounded; last segment of abdomen roundly emarginate; antennæ of male without appendage, the 3rd segment very long	*Eurymetopus*.
	Temporal margins usually angulate; last segment of abdomen convex, rarely angularly emarginate with two points	7.
7.	First segment of antennæ of male large, sometimes with an appendage, 3rd segment always with an appendage	*Goniodes*.
	First segment of antennæ of male enlarged but always without an appendage, 3rd segment without appendage; last segment of abdomen rounded behind	*Goniocotes*.
vi.	Third segment of antenna of male without an appendage	*Ornithobius*.
	Third segment of antenna of male with an appendage	8.

8. { Front deeply angularly notched *Bothriometopus.*
Front not angularly notched 9.

9. { Antennæ and legs long; a semicircular oral fossa *Lipeurus.*
Antennæ and legs short; oral fossa narrow, elongate, extending as a furrow to the anterior margin of the head *Oncophorus.*

2. AMBLYCERA.

a. Tarsi with one claw; parasitic on mammals =*Gyropidæ*, with one genus, *Gyropus.*

b. Tarsi with two claws; parasitic on birds (? except *Boopia*) *Liotheidæ.*

LIOTHEIDÆ.

Ocular emargination distinct, more or less deep i.
Ocular emargination absent, or very slight ii.

i. { Forehead rounded, without lateral swellings; antennæ projecting beyond the border of the head *Colpocephalus.*
Forehead with strong lateral swellings 3.

3. { Antennæ projecting beyond the border of the head; temporal angles projecting rectangularly; eyes large and simple *Boopia.*
Antennæ concealed in a groove on the under side of the head; temporal angles rounded or slightly angular; eye divided by an emargination and fleck 4.

4. { Mesothorax separated from metathorax by a suture *Trinoton.*
Mesothorax and metathorax fused without suture *Læmobothrium.*

ii. { Sides of head straight or slightly concave; forehead with two small laterally projecting labral lobes *Physostomum.*
Sides of head sinuous; forehead without labral lobes 5.

5. { Body very broad; metathorax shorter than prothorax *Eureum.*
Body elongate; prothorax shorter than mesothorax 6.

6. { Ocular emargination filled by a strong swelling; sternal markings forming a quadrilateral without median blotches *Nitzschia.*
Ocular emargination without swelling, hardly apparent or entirely lacking; median blotches on sternum 7.

7. { Very large, with two-pointed appendages on the ventral aspect of the hind head; anterior coxæ with very long lobe-like appendages *Ancistrona.*
Small or medium, without bipartite appendages of hind head *Menopon.*

CHAPTER XVIII

Order Hymenoptera: Ants, Bees, Wasps, etc.

(Gr. ὑμήν = a membrane; πτερόν = a wing).

A VERY large order of insects which, typically, have two pairs of wings of moderate size—the hind pair being the smaller—and with few or no cross-veins. The mouth-parts are formed for biting hard things as well as for taking up liquid food, so that well-formed mandibles are always present. In the female the abdomen ends in an ovipositor of some sort, or in a sting which is a modified ovipositor, and the ovipositor when not in use, may be either retracted or exposed. The metamorphosis is "complete."

The head is, in a general way (and the mouth-parts being excepted) a good deal like that of *Diptera*, and is very mobile. The mandibles are powerful, hinged biting-organs, which fold across the labrum; the maxillæ and labium may form a complicated proboscis.

The thorax is peculiar in several ways: the pleura of the prothorax are detached from the pronotum and are thrown forward, carrying the front legs with them; the true 1st abdominal segment is incorporated with the thorax, so that the apparent 1st abdominal segment is really the 2nd segment of the abdomen. In most of the stinging *Hymenoptera* the trochanter of the legs consists, as usual, of a single piece; but in most of the stingless *Hymenoptera* the trochanter is divided into two segments.

The wings of each side are usually yoked together for concerted action by a row of hooked bristles or hairs on the front edge of the hind wing, which, when the wings are expanded, catch a vein or a fold in the hind edge of the front wing. In some females, and in the workers (which

are sterile females) of some of the social forms wings are absent, but males are rarely wingless. On either side of the mesonotum above the roots of the front wings there is articulated a plate, known as the *tegula*, the size and form of which is of some importance in classification.

The abdomen is either broadly connected with the thorax, in the common fashion, when it is said to be "sessile," or it is contracted anteriorly to a slender "waist," when it is spoken of as stalked or "petiolated."

The eggs are deposited either (1) in the tissues of plants, or (2) in or on the eggs or larvæ of other insects, or (3) in special "cells" or chambers constructed by the parent (or foster-parent in the case of most social Hymenoptera); in the last case provision for the ensuing larva may be enclosed in the same chamber with the egg, or the egg and its issue may be the object of sustained solicitude to the parent (or foster-parents).

The larva may be caterpillar-like, with thoracic legs and abdominal pseudopods; but more commonly it is legless and maggot-like, though with the head larger and more distinct than it is in the Dipterous maggot. The larva (1) may feed on plants, or (2) may be a parasite in the tissues of plants, in which case it sometimes forms galls, or (3) may be parasitic in the egg or larva or pupa of another insect, or (4) may be provided for by the parent in various ways that simulate conscious forethought.

The pupa may be enclosed in a cocoon, or not; its wings and appendages are not bound down by chitinous exudation as in the obtected pupa of certain other insects. When the larva has lived in a special chamber or "cell," constructed by the parent or foster-parent (worker), the pupa continues to occupy the chamber, in which it may either spin a cocoon or not.

Parthenogenesis is very common in this order; and among some gall-flies (*Cynipidæ*) a parthenogenetic generation regularly alternates with a sexually produced generation.

A good many of the stinging Hymenoptera live in communities. The organisation of these communities varies considerably, but a typical community consists of (1)

a queen, or female parent; (2) of males, whose existence is transient and perhaps precarious; (3) of workers, which are sexually arrested females and may be all alike or may be of more than one caste; and (4) of eggs, larvæ, and pupæ. The chief business of the workers is to house, provide for, and nurse the developing larvæ. The queen produces the eggs, and the ultimate issue of the eggs is only to a certain extent predetermined: males are supposed to be the predestined issue of unfertilised eggs, while the destiny of the larvæ issuing from fertilised eggs—whether they shall be sexually perfect females (queens) or sterile females (workers)—appears to depend upon the amount and quality of the food administered to the larva at a particular stage of its development. All the individuals of a community—workers, females, and males—may be alike, as with the social wasps; or they may be unlike, as with the social bees; or the workers may not only be unlike either sex, but may be split into structurally different castes *inter se*, as among many ants.

From the economic standpoint the great order *Hymenoptera* is of prime importance; but the medical officer has to regard chiefly the Aculeate Hymenoptera that may inflict venomous wounds, and those species of parasitic and predaceous Hymenoptera that prey upon Diptera. The latter question is complicated by the facts that some of these also prey upon spiders and upon other insects that themselves are enemies of Diptera, and that some of the Dipterous victims are not, to say the least, known to be harmful.

The Hymenoptera are arranged in two suborders, which are named, according to the form of the abdomen, *Sessiliventres* and *Petiolata*.

1. SESSILIVENTRES. The abdomen is broadly connected with the thorax, so that there is no "waist"; the trochanter of the legs is composed of two pieces; the larva is caterpillar-like, but can be distinguished from the Lepidopterous caterpillar by the fleshy abdominal legs, or pseudopods, being more numerous, being always present on the 2nd abdominal segment, and having no hooklets; sometimes the larva is sluglike. The suborder includes, among other forms, the Saw-flies (*Tenthredinidæ*), whose larvæ feed on plants and

damage crops, and the Horn-tails (*Siricidæ*), whose larvæ bore into the trunks of trees and spoil timber. In the Saw-flies the ovipositor consists of a pair of broad plates, serrated on the ventral edge, which are retractile into a pair of sheaths; in the Horn-tails the ovipositor is a long slender tube embraced by a pair of long slender sheaths.

2. PETIOLATA. There is a "waist" formed by the true 2nd (apparent 1st) abdominal segment, or sometimes by the true 2nd and 3rd abdominal segments; it may be of great length, or it may merely be a constriction, and it gives the abdomen very free play. The larva has no legs. This enormous suborder is arranged in three divisions, namely: (i) the parasitic Hymenoptera, or *Parasitica;* (ii) a small intermediate group in which the ovipositor is peculiar and retractile and has something the look of a sting—the *Tubulifera;* and (iii) the true stinging Hymenoptera, or *Aculeata.*

i. *Parasitica.* The female has an ovipositor, not a sting; the trochanter of the legs is usually composed of two pieces. This group includes a prodigious number of Hymenoptera, many of which are minute, though some are of good size. The larvæ of some of them are vegetable-parasites, and form galls on plants; but the larvæ of the great majority are parasitic generally in (sometimes on) the larvæ or pupæ, sometimes in the eggs, of other insects. The victimised larva is not immediately killed, but lives for some time, and may even, in due season, pupate; but if this happens, the parasitic Hymenopteron continues to live at the expense of the victim-pupa and ultimately pupates in the latter, so that for the latter all is vanity. The parasitic Hymenoptera thus destroy a vast number of insects—chiefly caterpillars, but also aphides, the larvæ of beetles, Dipterous maggots, etc.; it is a common experience in the tropics to find that an insect larva which is being bred with a view to specific identification yields from its pupa nothing but parasitic Hymenoptera. The following families may be noticed:—

(a) *Cynipidæ;* Gall-flies. These are small, or minute, Hymenoptera, usually of a shiny black colour: they may be recognised by the relatively enormous size of the terga of one or two of the anterior segments of the abdomen and the telescoped appearance of the posterior segments, and by the

absence of a *stigma*, or opaque spot near the middle of the anterior margin of the front wing: the larvæ live in galls (of which the oak-apple and the mossy rose-gall are good examples), which are *closed*, so that the insect when transformed has to eat its way out.

(b) *Ichneumonidæ;* Ichneumon-flies. Though some of these are minute, many are of large size. The body is long and slender and, in the female, ends in an ovipositor which is sometimes of enormous length; the antennæ are long and slender. The eggs are commonly laid in caterpillars, which are ultimately killed by the larvæ.

(c) *Chalcididæ* (Fig. 98). These are usually small, often very minute, and generally have a bronzy sheen (χαλκός = copper or brass). The wings have no cells and usually only

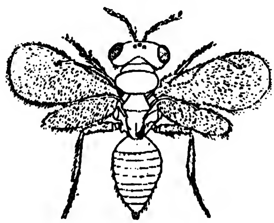

FIG. 98.—A Chalcid Fly, greatly enlarged.

a single vein, which branches, and they are generally covered with fine hairs. Most of the species of this large family are parasitic on the larvæ, pupæ, or eggs of other insects, and it has been observed of late that the maggots of several species of *Muscidæ* are subject to the mortal attack of Chalcis-flies, a fact which is of importance to the medical officer.

(d) *Proctotrypidæ*, or *Oxyura*. These also are minute insects resembling the Chalcis-flies in form and habits, but differing from them in the absence of metallic lustre and, as regards the female, in having the abdomen pointed, with the ovipositor issuing from its tip.

ii. *Tubulifera*. This division includes the single family *Chrysididæ*, or Cuckoo-wasps. These are easily recognised by their brilliant (often green) metallic lustre; by their thick, extremely hard, coarsely pitted exoskeleton; by their ability to roll themselves up, owing to the ventral surface of the abdomen being concave; and by the long, transversely

segmented ovipositor. The *Chrysididæ* lay their eggs in the cells of the fossorial wasps, and their larva devours either the larva of the latter or the paralysed insects that have been laid up for its food.

iii. *Aculeata*, or Stinging Hymenoptera. This division includes the Bees, Wasps, and Ants. The trochanter usually consists of a single piece; the abdomen is generally composed of 6 visible segments in the female, and 7 in the male; the females (and the "workers," or sterile females, of the social forms) possess a sting. The sting is a modified ovipositor, although it does not give passage to eggs. It consists, in the bee, of a group of three spines which enclose a channel. The more central of the three is a fixed guide upon which the other two run. The reservoir of the venom gland opens at the base of the guide, and the venom is pumped along the channel aforesaid by the play of the two movable spines. The whole sting is enclosed in a sheath and is retractile. The potency of the venom differs in different species; and with any given species the hurt of the wound inflicted depends upon the depth to which the sting penetrates, since the deeper it goes the greater is the amount of venom forced along its channel. The venom of bees and wasps not only causes painful local inflammation, but also has general constitutional effects. Bee-venom is said to contain toxins that cause paralysis (neurotoxins), as well as toxins that damage the red blood-cells (hæmolysins). In the case of a single sting from a casual bee or wasp the local effects are dangerous only when the sting is in some place (mouth, throat, etc.); where sudden swelling may obstruct the breathing-passages, and the general effects are alarming only in certain persons who are peculiarly susceptible, and in enfeebled persons. In the case of a number of simultaneous stings, however, the result may be fatal to a strong person free from any idiosyncrasy, and numerous instances are known of men and large animals rapidly succumbing to the injuries inflicted by a swarm of infuriated bees or wasps; and it is said that the simultaneous attack of even a few hornets may be fatal to a human being.

Stings may be treated locally with alkaline lotions (ammonia, or carbonate of soda or potash), oxidising lotions

(permanganate of potash, hypochlorite of lime) or astringent lotions (sulphate of zinc, or sulphate of copper, weak solution of perchloride of mercury, or alum); carbolised oil also relieves pain, as does belladonna, chloroform water, or a mixture of friar's-balsam and thymol. When constitutional symptoms are manifested, stimulants, such as alcohol, ammonia, ether, and strychnine may have to be given.

The larvæ of the stinging Hymenoptera are soft grubs without legs, and are protected in cells made by the parent, or—in the case of the social forms—as a rule by the foster-parent (worker).

The Aculeata are grouped in four sections, namely, *Anthopila*, or Bees; *Diploptera*, or Wasps; *Fossores*, or Digger wasps; and *Heterogyna*, or Ants.

(a) *Anthophila* (ἄνθος = a blossom, φιλέω = I love), or *Apidæ*. The bees are distinguished by the usually hairy body, many of the hairs being *feathered;* by the broadening and other modification of the first joint of the tarsus (and sometimes also of the tibia) of the hind leg; by the development of the labium and maxillæ to form a long or short proboscis; and by the fact that the "waist" is merely a constriction, not a slender stalk. The females ("workers" included) possess a sting, but there is a group of small bees which are commonly called stingless, since the sting, though present, is not functionally perfect. The habits of the honey bees are well known; but there are solitary bees, bees that are gregarious but not social, and bees that are parasitic on other bees in a sort of cuckoo fashion. The honey bees live in organised communities, consisting of a queen, an army of workers, and a small number of idle males (drones). The workers make cellular combs of wax secreted by glands on the ventral face of the abdomen, and during the summer they store some of the cells with honey and pollen, and rear the larvæ of the community—an egg being laid in each such cell by the queen—in others. The idle males perish in the autumn, but the queen and workers live through the winter on the food stored in the combs. New swarms are formed by emigration, the band of colonists consisting of a queen and a swarm of workers: these settle, and when the colony has made some increase, the original colonists begin to store

up honey and pollen. Honey is the nectar of flowers regurgitated from the bee's crop after undergoing certain changes there. The bumble-bees also live in communities which, like those of social wasps, die off in the autumn and are independently renewed in the spring by casual females which have managed to survive winter. The gregarious (non-social) bees make a common gallery, in which each mother makes her own cells and fills them with a mixture of honey and pollen before laying an egg in each and closing it up. The solitary bees make nests of many kinds; of bits of dry wood in holes drilled in timber (carpenter-bees); of pieces of leaf specially cut, and folded or gummed together (leaf-cutting bees); of stones and specially made cement (mason-bees); of resin; of cotton; and of wool. All kinds of bees—solitary, gregarious, and social—are much liable to the attacks of parasites.

(b) *Diploptera* (διπλοῦς = doubled; πτερόν = wing). This section includes the Solitary wasps (which must not be confused with the Fossorial wasps of the next section) and the Social wasps. Wasps can be distinguished, in life, by the fact that the front wings in repose are folded double, the bend running longitudinally from the base to the tip of the wing. The tarsi of the hind legs are not dilated, and there are no *feathered* hairs on the body. Wasps, though they may eat our fruit and jam, are chiefly carnivorous, and prey largely upon Diptera. They should therefore be protected, and the medical officer should never be weary in explaining that wasps, however furiously they may appear to rage, do not sting unless they are molested. The females of the Solitary wasps (*Eumenidæ*) make cells of clay which they fill with caterpillars for the expected larva to feed upon: the egg is suspended from the roof (so as not to be injured by the movements of the imprisoned caterpillars) before the cell is sealed up. The Social wasps live in communities consisting, to begin with, of a queen, and workers, which are like her in everything but size and the condition of the reproductive organs. The community is founded in the spring by a female (queen) which has chanced to survive winter: she merely begins the comb, lays an egg in each (unfinished) cell, and rears a brood of workers: these complete and enlarge the

comb and take charge of the larvæ afterwards produced from the queen's eggs. In late summer males and perfect females are produced: in autumn the community dies off, except for such females as may succeed in hibernating. Wasps' nests are constructed of a sort of paper made of mashed vegetable-tissue; the combs are generally placed in tiers. Even in hot countries like India, the wasp communities die off at the approach of the cooler season.

(c) *Fossores* (Lat. *fossor* = a digger, or miner). The fossorial wasps are never social, and rarely gregarious. Some of them—chiefly certain forms in which the female is wingless and ant-like—are "parasitic" in the same way as Ichneumon-flies, etc. (*i.e.*, the female victimises the larva of some insect as a living receptacle for her eggs and a living pabulum for the ensuing larvæ); but with most of them the female lays her eggs either in burrows or in specially constructed cells of mud, depositing in each cell, along with an egg, a provision of insects or spiders for the sustenance of the future larva, and then sealing up the cell, and, as a rule, leaving it to fate. The insects so used as provision are, usually, not killed but are paralysed or narcotised by a sting delivered in some non-vital part; and as a rule each species of wasp prefers a particular kind of insect for its purpose. A few Fossores have a slight resemblance to bees, but can be distinguished by the unmodified hind legs and by the absence of feathered hairs; some, with wingless females, resemble ants, but can be distinguished by the absence of nodes on the stalk or petiole of the abdomen; but the great majority look like wasps, from which they can be distinguished by the absence of the longitudinal fold of the front wing. The following families may be noticed:—*Pompilidæ*—large fossorial wasps, sometimes 2 or 3 inches long, and probably able to inflict a grievous sting; the pronotum is of good size and the hind legs are very long: they run rapidly, quivering with energy, and they store their cells with paralysed spiders. *Sphegidæ*—the pronotum is short, often a mere collar, in this very large family; the different species store their cells with insects of all sorts as well as spiders, each species according to its wont. The genus *Bembex*, in this family, requires particular notice, as its prey consists of *Diptera*, and it has

been observed in three different quarters of the globe to have a predilection for blood-sucking flies of the Tabanid family. The species of *Bembex* resemble heavy-built wasps, the "waist" being a constriction and not a long slender stalk; their colour is black or brown, with sinuous, or V-shaped, yellow, or milky cross-bands on the abdomen; the head is broad, the eyes are large, and the labrum is usually long and pointed; the legs are stoutish and spinose, and the tarsi are hairy. The female *Bembex* makes loose burrows in sand, not troubling to keep the mouth of the burrow open. In each loose cell she deposits an egg and a small provision of dead flies. The larva finishes this supply soon after hatching, and then the mother continues to feed it with fresh-caught flies as birds feed their nestlings. The larva of one species of *Bembex* is known to live fourteen or fifteen days before pupating, and is believed to consume between fifty and eighty flies. Some species of *Bembex* are gregarious (not social). One species of *Bembex* is known to be victimised in turn by a Tachinid fly, which lays its eggs on the prey as it is being carried by the mother to her larva; the eggs of the Tachinid are thus introduced into the nest, and hatching there, the Tachinid larvæ play the part of cuckoo, being fed by the *Bembex* at the expense of her own larva, which at last they may even kill and eat.

(d) *Heterogyna*, or *Formicidæ;* Ants. Ants are distinguished from other Aculeate Hymenoptera by the structure of the stalk or petiole that connects the "thorax" with the "abdomen"; the one or two segments that compose the petiole are extremely mobile and bear a dorsal node or "scale." The mouth-parts also are peculiar, the maxillæ and the labium, and their palps, usually being packed close together so as to give the utmost freedom to the powerful mandibles. The antennæ are elbowed. All the ants are social, though with some few species the communities consist of a very small number of individuals. The typical ant-communities are large and are composed of one or more usually winged queens, and of myriads of wingless workers (sterile females), which may be of more than one kind. The communities are lodged in a labyrinth of chambers and galleries near the surface of the ground (ant-hills), or far

underground, or among roots, or in decayed timber. Some ants make nests in trees, and there is a well-known Indian ant of fierce disposition that makes its nests of living leaves which are stuck together by sticky secretion expressed from the larvæ of the ant, the ants holding the larvæ in their mandibles and using them much as we might use tubes of "stickfast." The queens of the community, as usual, produce the eggs, which are taken charge of by the workers. The larvæ are not enclosed in separate cells, but are kept together, and are moved about as convenience or necessity may require; they are fed and carefully tended by the workers. The pupæ, which also are carefully looked after, are popularly known as "ants' eggs." The issue of the pupæ may be wingless workers after their several kinds, or may be winged males and females. Whether the particular issue be due to diet during the larval stage, or not, is not certainly known. The males and females periodically swarm out of the nest for a nuptial flight, soon after which the males die, and the impregnated females remain as potential queens. The communities are long-lived. New communities may be formed by a solitary female, as in the case of wasps and bumble-bees, such a female discharging the double function of worker and queen until the colony is established, and then becoming a true queen devoted entirely to egg-laying. Some ants have proper stings, others have rudimentary stings and merely squirt out their venom.

It is unnecessary here to refer to the weird and wonderful complications of ant civilisation, in which the individual is nothing and the state is everything. So far may this principle be carried that in the interests of the community certain individuals of certain species become living puncheons for holding the communal honey. Hamlet's imagination tracing "the noble dust of Alexander till he find it stopping a bung-hole" could hardly find a baser or grotesquer use for the paragon of the insect world. It is well known that certain ants lay up stores of grain and other food; that many ants herd aphides, and even keep root-feeding aphides and many other insects in their galleries for the sake of the sweet juices that they yield; and that the leaf-cutting ants bring home bits of leaf and mash them up into balls for the culture

of a particular kind of fungus. Many of the militant ways of procuring slaves known to the historian are also practised by ants, and some of the enervating and demoralising results of "the peculiar institution" are illustrated by these insects. The dependent alien ant is also known to some of the ant communities, and ants also harbour numerous commensals and parasites of other Orders of Insects. The medical officer in the tropics observes the ant chiefly as an industrious and useful scavenger, but sometimes as a very troublesome pest in houses and laboratories. It is well to bear in mind that some of the small scavenging ants that come about houses have most catholic tastes and might possibly infect food, while on the other hand they may make havoc of termites, bugs, flea-larvæ, etc.

Having briefly reviewed those Orders of Insects—namely, the *Diptera*, *Siphonaptera*, *Rhynchota*, *Anoplura*, and *Hymenoptera*—which, whatever else may be said for and against them, include a considerable number of species that *do* commonly inflict, or *can* inflict, direct physical suffering upon man, by sucking his life-blood, or by inoculating him with pathogenic hæmatozoa, or by infecting his food, or by burrowing into his body, or by grievously stinging him, or by treating him in some other way that drives him incontinent into the arms of the medical officer, we must next turn our attention to the insects of those Orders that affect the individual human machine in a less direct and tragic fashion.

Among the insects of what from our point of view may be termed of secondary importance come, *outside the foregoing Orders*, (*a*) those that may endanger man's health and bodily comfort by corroding and corrupting his stored provisions and by damaging his habitations; and (*b*) those that eat his insect foes, and may therefore be looked upon as respectable allies of the sanitary department.

In the first of these conventional assemblages come a good many species belonging the Orders *Coleoptera* (Beetles), *Lepidoptera* (Moths), *Orthoptera* (Cockroaches), *Isoptera* (Termites), *Corrodentia* (Book-lice), and *Thysanura* (Fish-insects); these Orders, therefore, will now be reviewed very shortly.

CHAPTER XIX

Order Coleoptera: Beetles

(Gr. κολεός = a sheath; πτερόν = wing).

THE beetles are an enormous group of insects in which the front wings are hard and useless for flight but form covers, or *elytra* (ἔλυτρον = sheath or shard), that cover the hind wings and the back; sometimes the elytra are soldered together, sometimes they are short and leave the after part of the abdomen exposed. The hind wings, which are properly functional, are large and membranous, and have few veins. The mandibles, maxillæ, and labium are used for biting, and in general form are not unlike the same parts of a cockroach (*cf.* Fig. 112). The antennæ vary in structure and are used by systematists in classifying the order.

All 3 segments of the thorax are distinct, though the mesonotum and metanotum are covered by the elytra. The form of the sockets of the legs, or *coxal cavities*, is of taxonomic importance; they are said to be "closed" when they are complete rings, "open" when they are merely bights in the after-edge of the sternum. The coxæ of the hind legs are often broad plates which appear to belong to their sternum. The number of tarsal segments is variable, and is employed in classification.

The larva usually has a distinct head, 3 distinct thoracic segments, and 9 (occasionally 10) abdominal segments: there are commonly three pairs of thoracic legs; but legs are often altogether absent. A majority of beetle larvæ live concealed in wood and among roots, and these, as a rule, have a soft, whitish abdomen; but some larvæ are active and predaceous, and have the abdomen shapely.

The pupa also is usually buried in earth or timber; it is

generally soft, with its appendages free; but some pupæ make rough cases, some are chrysalises, and some pupate in their larval skin.

The order is of tremendous importance to the agriculturist and forester; certain species that infest stored and shipped grain and dry provisions provide at times a problem for the sanitary officer; and the medical officer must not forget that many beetles are active scavengers, and that there are numerous aquatic beetles which, both in the adult and larval state, are predaceous, and therefore are to be reckoned among the possible checks upon mosquito-larvæ.

The Coleoptera are commonly divided into seven sub-orders, as follows:—

(1) *Lamellicornia* (Lat. *lamella*=a small plate; *cornu*=horn, or antenna). The distal segments of the antennæ form a sort of comb or book of broad plates, which when closed up give the antenna a clubbed appearance. All the tarsi are composed of 5 segments.

(2) *Adephaga* (ἄδην=to satiety, and φαγεῖν=to eat). Antennæ filiform; outer lobe of maxilla often divided into a two-jointed palp, the true maxillary palp being present also. All the tarsi are composed of 5 segments.

(3) *Clavicornia* (Lat. *clava*=a club, and *cornu*=antenna). Antennæ usually clubbed, the terminal joints not being lamellate.

(4) *Serricornia* (Lat. *serra*=a saw, and *cornu*). Antennæ usually toothed along the inner border.

(5) *Heteromera* (ἕτερος=different; μέρος=a part, or segment). There are 5 tarsal segments in the first and second pairs of legs, and only 4 in the third pair.

(6) *Phytophaga* (φυτόν=a tree; φαγεῖν=to eat). The tarsi appear to be composed of 4 segments, the true 4th segment being reduced and invisible in a dorsal view. Head not produced into a snout.

(7) *Rhynchophora* (ῥύγχος=a snout; φορέω=I carry). Head usually produced into a snout. The tarsi usually appear to consist of 4 segments, the true 4th segment usually being reduced and hidden beneath the base of the true 5th.

Of the LAMELLICORNIA only the *Scarabæidæ* (Fig. 99)

need here be mentioned—large beetles, of which the well-known sacred "scarab" of the ancient Egyptians is a good illustration. The beetles of this family are numerous in warm countries. They have the habit of rolling dung into balls with their feet, and carrying off and burying the balls

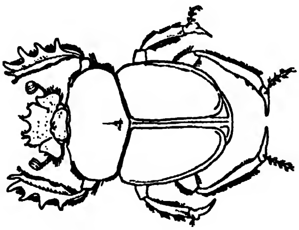

FIG. 99.—Scarab Beetle.

for food; at the breeding-season they roll larger balls for the reception of the eggs and the nourishment of the issuing larvæ. In countries where roads are merely tracks suitable for pack-animals, the scarabs do some service by clearing the roads of droppings.

Of the ADEPHAGA three families of useful predaceous beetles must be noticed, namely:—(a) *Cicindelidæ*, or tiger-beetles—long-legged, slender, graceful, active, and often pretty-coloured beetles; the inner lobe of the maxilla ends

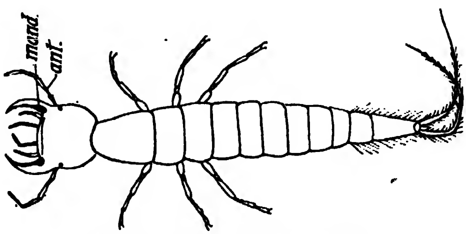

FIG. 100.—Aquatic Larva of *Dytiscus*

in an articulated hook; the larvæ are alert, and "lie doggo" for their prey in burrows. (b) *Carabidæ*, or ground-beetles—much like the tiger-beetles, but of somewhat stouter build, usually of a shiny black colour, and not having a hook to the inner lobe of the maxilla; the larvæ are active and hunt their prey, like their voracious parents. (c) *Dytiscidæ*—

these are largish water-beetles, with oval, somewhat flattened bodies, polished elytra, and feathered hind legs adapted for swimming: the larva (Fig. 100), which also is aquatic, has enormous channelled mandibles like those of the ant-lions, for seizing and sucking prey, and a tapering abdomen which ends in a pair of feathered lobes or filaments, the last 2 abdominal segments also being feathered.

Of the CLAVICORNIA eight families may be introduced to the medical officer, namely:—(a) *Gyrinidæ*, or whirligig-beetles, the adults and larvæ of which are aquatic and predaceous and may possibly (as may the *Dytiscidæ*) devour mosquito-larvæ. The whirligigs are often seen disporting in companies on the surface of the water, occasionally taking a sudden dive; the antennæ are short and blunt, and the middle and hind legs are paddles for swimming; the larva (Fig. 101) is long and slender, with a pair of gill-filaments

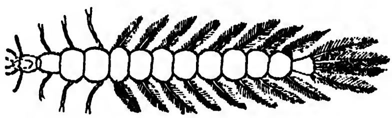

FIG. 101.—Aquatic Larva of *Gyrinus* (copied from Miall).

on each of the first 8 abdominal segments, two pairs on the 9th, and two pairs of hooks on the small 10th segment. (b) *Hydrophilidæ*—these also are water-beetles, and can be distinguished both from *Dytiscidæ* and *Gyrinidæ* by their antennæ, which are long and clubbed and consist of 9 distinct segments: the aquatic larva, which is rapacious, has neither the enormous channelled mandibles of *Dytiscus*, nor the feathered tracheal gills of *Gyrinus*, and its tapering abdomen ends in a pair of segmented hooks. (c) *Ptatypsyllidæ*—small blind beetles, with short elytra and no wings, and antennæ of 3 segments, the 3rd being impacted in the 2nd; parasitic in the fur of beavers. (d) *Leptinidæ*—small beetles, blind or with imperfect eyes, with properly formed elytra, and antennæ of 11 segments; parasitic on beavers and other smaller rodents. (e) *Silphidæ*—burying-beetles, with knobbed antennæ; well known by their habit of mining beneath and ultimately burying the dead bodies of small animals; the

larva is active and somewhat resembles a wood-louse. (f) *Staphylinidæ*—rove-beetles, devil's coach-horses; long slender beetles with short elytra that leave most of the abdomen uncovered; they have the habit of turning up the "tail" in a threatening manner; like the preceding family they are useful scavengers. (g) *Cucujidæ*—flat, usually elongate, brown or red beetles, common in warm countries; one species, *Silvanus surinamensis*, infests stored grain—it is a small beetle about one-eighth of an inch long, and can be distinguished from other beetles of similar habit by having the sides of the pronotum serrated. (h) *Dermestidæ* (Fig. 102)—notoriously destructive little beetles, the larvæ being specially harmful; one or two species are universally infamous as museum pests, but other species do great damage

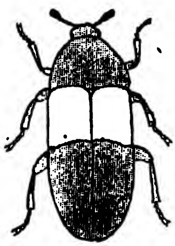

FIG. 102.—*Dermestes*, enlarged.

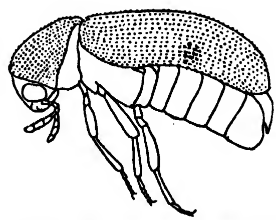

FIG. 103.—*Anobium paniceum*, enlarged.

to dried provisions, upholstery, and carpets. The adults are small, plump, brownish or greyish beetles, with clubbed antennæ that can be tucked into a groove in the under side of the thorax; the larvæ are covered with stiff, curved, beautifully barbed bristles, of uniform size, and very regularly arranged in transverse rows; the pupæ are loosely protected in the larval skin. A room infested with *Dermestes* is best dealt with by the ordinary method of sulphur fumigation. Iron bowls half full of sulphur—each bowl being set for safety in a basin of water—are ignited, and are left to burn themselves out in the infested room, every opening of which must be tightly closed and be kept closed until the following day. If there is any difficulty in igniting the sulphur a little spirit should be used. The performance must be repeated a few weeks afterwards to catch any larvæ that may hatch from eggs that may, very likely, have escaped the effects of the fumes.

Of the SERRICORNIA the only family that the medical officer requires to know is that of the *Ptinidæ*, or Death-watches. These are small beetles, in which the head is tucked under the pronotum and is often quite invisible in a dorsal view. Many of the species of this family are omnivorous pests of the household and warehouse. One of the worst is *Anobium paniceum* (Fig. 103), commonly known as the biscuit-"weevil," which destroys all sorts of things besides ships' biscuit, including grain, dried meat, and provisions generally, books, furniture, and even, it is said, opium. The larva of this species is a small sausage-shaped whitish grub; the adult on first emergence is light brown but soon becomes darker. Other species that eat everything they can get hold of, and are consequently of

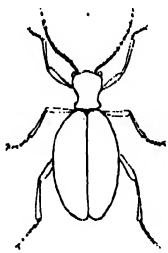

FIG. 104.—*Ptinus*, enlarged.

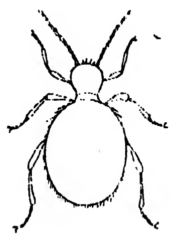

FIG. 105.—*Niptus*, enlarged.

very common occurrence, belong to the genera *Ptinus* (Fig. 104) and *Niptus* (Fig. 105). In *Niptus* the elytra are fused together. Another well-known species of Ptinid is the one that eats tobacco and drills neat holes into cigars, often choosing the best. Cigars that have been perforated by this little beetle regain their full charm if you have patience to smoke on until sufficient ash is formed wherewith to make a little paste and plug the hole.

Of the HETEROMERA two families attract the attention of the medical officer. (a) *Cantharidæ*, or *Meloidæ;* Blister-beetles. The integument is comparatively soft, the head is abruptly narrowed behind the eyes to form a sort of neck, the elytra are rather loose, and they sometimes overlap; the legs are long and slender, and each tarsal claw has either an appendage or a tooth. Some (*Meloinæ*) are wing-

less and have rudimentary elytra; others (*Cantharinæ*) are winged and are commonly found on flowers. *Cantharis vesicatoria* is the blister-beetle of the B.P., but many other species of the family have vesicant properties.

(b) *Tenebrionidæ.* A large family of dull-coloured beetles, several of which are known all the world over as extremely destructive to stored grain and meal. The commonest species is *Tenebrio molitor*, whose larva is the well-known meal-worm. Both larva and adult work havoc among the stores of millers, corn-chandlers, and bakers. The larva looks very much like a wire-worm, having the same long, stiff, cylindrical body, and the same yellowish-brown colour;

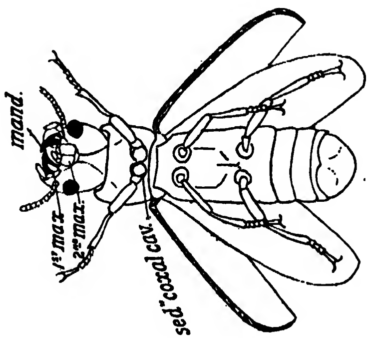

FIG. 106.—*Tribolium ferrugineum*, from damaged grain.

it is composed of a head with the usual appendages, and of 12 body-segments, each of the first 3 of which has a pair of very short legs; when full grown it is more than an inch long. The adult, which is a little more than half an inch long, is shaped very much like *Tribolium* (Fig. 106), but is almost black in colour. Another species which has been spread widely in cargoes of grain is *Tribolium ferrugineum* (Fig. 106), the adult of which is reddish-brown in colour, and less than a quarter of an inch long. *Gnathocerus cornutus*, another grain-pest, is much like *Tribolium*, but the male has enormous curved mandibles, which project like horns.

Of the PHYTOPHAGA also two families require notice:—

(a) *Bruchidæ*, or pea-weevils—the larvæ live in seeds, and *Bruchus pisi* and *fabi* are notorious pests of peas and beans. The adults of these are small plump beetles with the head produced into a broad beak, the hind femora more or less swollen, and the tip of the abdomen not covered by the elytra; the larvæ are fat maggots without legs (except when first hatched), and with a pair of broad serrated teeth on the pronotum. (b) *Chrysomelidæ*—an enormous family of small beetles destructive to plants; they are oval in shape, convex, and often of a bright metallic colour; the larvæ of some species do much damage to certain "root"-crops, among these is the larva of the notorious Colorado potato-beetle (Fig. 107).

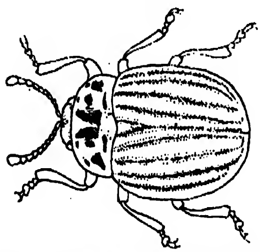

FIG. 107.—Colorado Beetle, enlarged.

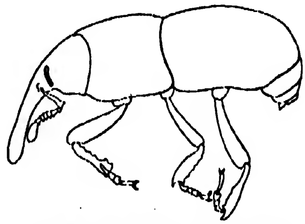

FIG. 108.—*Calandra*, much enlarged.

RHYNCHOPHORA. This enormous suborder includes the true weevils, most of which can be recognised by their long snout: they are mostly wood-borers and plant-eaters, but some are well known as destructive to stored grain—*e.g.* certain species of the genus *Calandra* (Fig. 108).

Order STREPSIPTERA.

(Gr. στρεψὶ = twisted, and πτερὸν = wing.)

Minute insects, of which the females are degraded, wingless, and legless endoparasites of certain *Hymenoptera* and *Hemiptera*. The short-lived males are active and well endowed, possessing large hind wings, which have no cross-veins, and vestigial front wings. The larvæ are parasitic in the larvæ of their mother's host. The *Strepsiptera* are now very commonly classed with the beetles (*Coleoptera*).

CHAPTER XX

Order Lepidoptera: Moths and Butterflies

(Gr. λεπίς, λεπίδος = a scale; πτερόν = wing).

THIS order includes the Butterflies and Moths, and although it is made much of by entomologists, and although, owing to the depredations of caterpillars, it is an order of grave concern to the market-gardener, the fruit-grower, the planter, and the forester, the medical officer comes in contact with it only in a sort of fancy way, when patients have handled caterpillars that have venomous hairs, or have passed or coughed up a caterpillar. The sanitary officer, again, may have to deal with grain and flour that has been damaged by the larvæ of certain moths.

In the Lepidoptera the wings are covered with scales, the mouth-parts form a long tube for sucking the nectar of flowers, and the metamorphosis is "complete."

The eyes are large and the antennæ are composed of many segments. The only conspicuous parts of the mouth, as a rule, are (1) the coarse, hairy, labial palps, and (2) the proboscis formed by the apposition of the extraordinary long, channelled maxillæ; this in repose is coiled between the labial palps. In some moths the maxillæ do not form a tube, or are absent altogether; and in one small family of moths the mandibles are well developed, and the maxillæ are used for feeding on pollen.

The mesothorax forms the chief part of the thorax; the prothorax is a mere collar, and usually bears a pair of shoulder-flaps, or *patagia*, which overhang the bases of the front wings. For united action the wings of each side are held together either (1, as in most moths) by a strong curved bristle, or leash of bristles, known as the *frenum*,

which projects from the root of the hind wing and bites into a flap or tuft of scales, known as the *retinaculum*, on the under side of the front wing; or (2, as in butterflies and some large moths) by a flange of the inner part of the anterior border of the hind wing, which rides under the front wing; or (3, as in a few moths) by a slender finger-like stay, known as the *jugum*, which projects backwards from the axil of the front wing. The scales that cover the wings are arranged in regular overlapping rows like the slates on a roof. The colouring of the wings is effected by the scales, and is due either to pigment, or to surface diffraction of light, or (in the case of white) to occluded air. The females of some moths are wingless.

The abdomen, which like other parts of the body, is thickly covered with hairs or scales, is composed in the male of 8, in the female of 7, visible segments.

The eggs, which are of varied shape and sculpture, are often laid on the particular food-plant of the larva. The larva, or caterpillar, has a distinct head and powerful mandibles; 3 distinct thoracic segments, each, as a rule, with a pair of short legs, which are segmented and end in a claw; and 10 abdominal segments, the last of which, and generally some of those in front of it, bears a pair of fleshy, unsegmented *pseudopods* the tips of which are burred with minute hooklets. The larva has a pair of silk-glands which open at a prominence, the *spinneret*, in the middle of the labium: it feeds voraciously, usually on foliage, but sometimes burrowing into leaves, or into fruits and seeds, rarely upon animal matter. The pupa in most butterflies is "obtected," *i.e.*, is an exposed chrysalis physiologically protected by the hardened secretion or pupal skin that binds down all the appendages; but in most moths the pupa is, further, mechanically protected by a cocoon of some sort, which is constructed, in whole or part, of silk spun by the larva when preparing to pupate.

The order is composed of two groups—*Rhopalocera*, or Butterflies, and *Heterocera*, or Moths.

In the *Rhopalocera* (ῥόπαλον = a club; κέρας = antenna) the antennæ are clubbed at the tip, the wings are held together by a flange of the posterior wing, and when the

wings are closed they stand vertically upright. Some authors separate as a distinct group the Skippers, which, though they have the general carriage of a butterfly, are stout and thick set, and have antennæ that, being thickened near, not at, the tip, are not truly clubbed.

The *Heterocera* (ἕτερος = different; κέρας = antenna) rarely have clubbed antennæ, and usually have the wings linked together by a frenum and retinaculum; the wings, in repose, usually are sloped on either side of the body. A good many moths are as diurnal as butterflies, but the majority are active after sunset. The moths far outnumber the butterflies in species.

The medical officer should be able to recognise the following families of moths, which include certain species whose caterpillars possess spines or hairs that are known to have irritating properties when they are touched:—

Saturniidæ. Large moths, some of them enormous, found in all parts of the world, and in India known as tusser-silk-moths. The wings often have transparent "windows," or large staring eye-like markings, or the hind wings are produced into a long "tail." The caterpillars are often remarkably coloured, and are ornamented with fleshy tags, or with warts bearing spines which may be venomous.

Limacodidæ. Smallish, stout moths, many of which have a good deal of apple-green in the colouring. The caterpillars

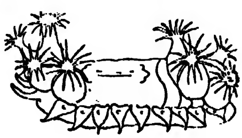

FIG. 109.

(Fig. 109) are broad and oval, and have no pseudopods; they are commonly known as slug-caterpillars; the sides and back often bear warts and excrescences beset with spines and hairs. The cocoon is dense and has a lid.

Megalopygidæ. A small American family. The full-grown larva of one species is said to resemble a lock of hair; under the long hair there are short stiff poison hairs.

Lasiocampidæ. Eggar-moths and lappet-moths; largish, stout, thickly-furred moths, often beautifully mottled in brown. The eggs are sometimes embedded in hair shed by the parent, so that when they are laid in rows the mass resembles a strip of felt. The caterpillars are very woolly and hairy, as also is the cocoon: the hairs of a South African species of *Metanastria* are said to be thrown off by the caterpillar and to be particularly irritating.

Lymantridæ. Tussock moths; smallish white, or grey, or dingy, hairy moths, the adult female often wingless or with imperfect wings. The eggs are often protected with hair. The caterpillars have brightly coloured tufts of hair which may be venomous.

The following families include species which are notorious pests in houses and granaries:—

Pyralidæ. A very large family of small, plain-coloured moths, often with long legs and a few cross-markings on

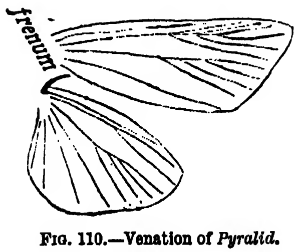

FIG. 110.—Venation of *Pyralid.*

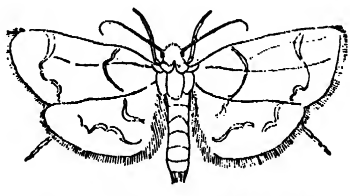

FIG. 111.—*Pyralis farinalis*, enlarged.

the fore wings. They can be distinguished, if the wings be mounted in Canada balsam so as to make the scales transparent, by the wing-venation (Fig. 110). The larvæ, which are usually naked and dingy coloured, protect themselves with silky threads and entangled debris; some of them do great damage to stored grain, flour, etc., one of the most notorious being *Pyralis farinalis*, the adult of which is shown in Fig. 111. Fumigation with carbon bisulphide has been recommended for infested granaries and mills; but it must not be forgotten that this compound is explosive.

Tineidæ. An enormous family of small or minute moths, usually with narrow, shiny wings having particularly broad fringes; the broad-winged species must be distinguished

by the wing-venation (Fig. 112). The larvæ burrow in leaves and in all sorts of other things, including wood, corks of bottles, stored grain, dried fruits, potatoes, horn, fur, and clothes. Three species of clothes-moths (*Tinea*) are known: *T. pellionella* is brown with a few dark spots on the fore wings; its larva makes a portable case out of fragments of the stuff it eats, and finally pupates in the case: *T. tapetzella* has black and white fore wings; its larva also constructs a case: *T. bisselliella* is straw coloured; its larva does not make a case until it is ready to pupate. Clothes-moths can easily be kept off by the use of the volatile

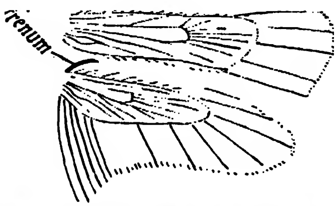

FIG. 112.—Denuded Wing of *Tinea*; the fringe merely indicated.

insecticides known to all housekeepers, and by periodical airing of clothes; simple wrapping in brown paper may be sufficient.

Tortricidæ. A large family of Micro-Lepidoptera with the wings broader and not so deeply fringed as those of the Tineids, and the venation of the hind wings slightly different. The larvæ are known as leaf-rollers, but some burrow in fruit, nuts, and seeds. "Jumping-beans" are seeds that are inhabited by a living larva of a Tortricid.

CHAPTER XXI

Orders Orthoptera, Isoptera, Corrodentia, and Thysanura

THE Orthoptera (ὀρθός = straight, *i.e.*, in respect of the fold of the wings, and πτερόν = wing) have mouth-parts formed for biting (Fig. 113). The front wings are stiff, and form covers or *tegmina* (Lat. *tegmen* = a cover) for the hind wings. The hind wings are membranous, with radiating veins connected by short cross-veins to form a network, and

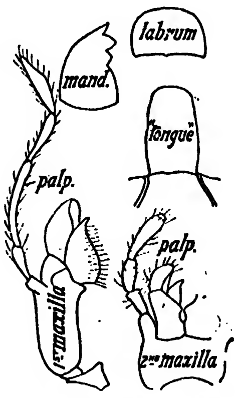

FIG. 118.—Mouth-parts of Cockroach.

when closed they lie in longitudinal folds, like a fan. Numerous species have no wings, or only rudiments of them. There is no abrupt metamorphosis; the young resemble the adult, except in the absence of wings, which appear as buds at an early moult and gradually increase in size in the course of successive moults.

The Order embraces earwigs, cockroaches, praying-mantises, stick-insects, leaf-insects, grasshoppers, locusts, and

crickets. It is a large one, and includes many insects that are terribly destructive to vegetation. It is of hardly any direct importance to the medical officer; but indirectly it concerns him, since in districts where the population is immediately dependent on agriculture, the damage done to growing crops by visitations of locusts may cause scarcity, which may bring in its train the usual famine diseases.

The Orthóptera are usually grouped in two suborders, namely, (1) *Cursoria* (Lat. *cursor* = a runner), in which the hind legs differ but little from the other legs; and (2) *Saltatoria* (Lat. *saltare* = to leap), in which the hind legs are longer and usually much stouter than the other legs, and are used for leaping.

Suborder CURSORIA.

This suborder includes five families, namely, earwigs, the curious parasite *Hemimerus*, cockroaches, praying-insects, and stick- and leaf-insects.

Family *Forficulidæ:* Earwigs (Lat. *forficula* = a pair of small shears). Earwigs are easily recognised by the pair of strong pincers at the end of the abdomen. The tegmina are short, and the wings are packed in a peculiar manner, being folded first lengthways like a fan, and then again crossways in reversed folds. In a good many earwigs the wings, and in some the tegmina also, are absent. Earwigs gnaw flowers and fruit, but they are also carnivorous. An Indian species with very long pincers has been seen to use these organs for carrying prey. A diminutive tape-worm of rats (which also occurs in man occasionally) has been found in its cysticercus stage in an earwig.

Family *Hemimeridæ.* The one or two West African species that constitute this family look something like

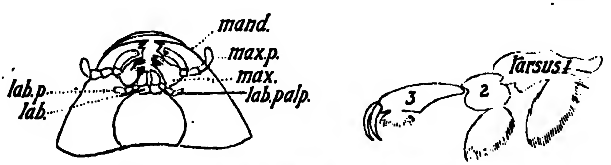

FIG. 114.—Head and Tarsus of *Hemimerus*, enlarged.

wingless cockroaches, but the coxæ are small; there are only 3 tarsal segments, and these have hairy, sucker-like pads on the under surface; the head is not inflexed, and the mouth-parts (Fig. 114) are peculiar. The abdomen ends

in a pair of long, *unsegmented* filaments (anal *cerci*) like those of a cricket. *Hemimerus talpoides*, from tropical West Africa, is parasitic on a rat (*Cricetomys*), and is further peculiar in bringing forth its young alive.

Family *Blattidæ* (Lat. *blatta* = a beetle). This family includes the cockroaches, of which there are many species besides the familiar kitchen pests. Cockroaches are distinguished by their flat body and strongly deflexed head, and by their large coxæ, which completely cover the weak sterna of the thorax. In both sexes segmented anal cerci are present, though in some cases they are small and concealed; and the males also have a pair of anal styles. The adults may be either winged or wingless. The eggs are laid in chitinous capsules shaped something like a bean; but viviparous Blattidæ are known. The usual domestic species are the dark-coloured *Periplaneta orientalis*, the lighter coloured *Periplaneta americana*, and the small *Phyllodromia germanica*. The habits of these are only too well known. They seem to eat everything; but they do more damage in warm countries than they do in England, where they seldom leave the moisture and warmth of cellars and culinaria. Though no specific charge has been brought against the domestic cockroach, it is quite reasonable to infer from the habits of the insect that in its contact with food and utensils it sometimes must be an agent of infection. On the other hand, the cockroach is said to have almost a predilection for bed-bugs as prey. Where cockroaches are a nuisance, their haunts may be treated with creasote, or dilute formalin, which are more lasting in their effects than insect-powder. The intestine of the cockroach is the home of several interesting Protozoa and worms.

Family *Mantidæ* (μάντις = a soothsayer). The Mantids, or Praying-insects, are recognised by the peculiar form and attitude of the front pair of legs; these are much enlarged, and in repose are folded and uplifted as if in prayer; in action, however, they are formidable instruments for striking and grasping prey, the tibia closing on the femur as the blade of a pocket-knife shuts on its shaft, and the opposed

surfaces of both tibia and femur being sharply serrated. The prey consists of soft insects, such as flies, which are devoured struggling. The eggs are laid in capsules or in spumous masses attached to leaves and twigs. Mantids often show most wonderful deceptive resemblances in colour, and also sometimes in form, to plant-life, such as lichens, leaves in their various phases, and flowers. It is stated in the *Cambridge Natural History* that in Melbourne a common local species of Mantid is kept on window-blinds to catch flies. It must be remembered, however, that Mantidæ do not naturally frequent houses, although they live and breed quite well in captivity. In the tropics young Mantises can easily be bred up from the egg (by any one wishing to domesticate them as fly-catchers) by keeping them in a cage with a rotting banana: the banana in this state nourishes first in the maggot form, and then in the adult form suitable to the tiny Mantises, an unceasing stream of minute Muscoid flies.

Family *Phasmidæ* (φάσμα = a phantom): Stick-insects. The insects of this family can be told by their wonderful resemblance to pieces of dry stick and thorny stalks, but some, as the females of the leaf-insects (which also belong to this family), exactly simulate leaves. There are some wingless grasshoppers and some bugs (*Rhynchota*) which also resemble pieces of stick; but the former can be discriminated by the fact that the elongation of the thorax is contributed chiefly by the *prothorax*, and the latter are at once recognised by their suctorial beak. The eggs of stick-insects resemble seeds, and are said usually to be scattered; but there is a species found in Calcutta that lays its eggs in a neat double row on leaves. Some of the stick-insects have wings, others are wingless. These insects feed on vegetation, and therefore have not raptorial legs. Some *Phasmidæ* are said to be able to eject, from glands situated in the thorax, an acrid fluid which, if it gets into the eye, may cause blindness.

Suborder SALTATORIA.

In this suborder the hind legs are enlarged for leaping, and organs for the production and also for the perception of sound are usually present. The suborder includes three families: *Acridiidæ*, or short-antenna grasshoppers; *Locustidæ*, or long-antenna grasshoppers; and *Gryllidæ*, or crickets and mole-crickets; but these families are not so sharply separated from each other as are the families of *Cursoria*.

Family *Acridiidæ* (ἀκρίς = a locust): Locusts and Short-antenna Grasshoppers. Among the *Saltatoria* the members of this family are

distinguished by the following combination of characters:—The antennæ are comparatively short, consisting of less than 30 segments; the tarsi consist of only 3 separate segments; and in the female there is no projecting ovipositor. Moreover, the auditory drums lie in the 1st abdominal segment, just behind and above the articulation of the hind legs. The chirping of these grasshoppers is usually performed by rubbing the inner surface of the hind femur—where there is a row of small pegs—against the outer surface of the tegmen or front wing—where there is a prominent sharp-edged vein; and this apparatus, though not confined to the male, is peculiarly well developed in that sex. The name "locust" is applied to about half a dozen species of large *Acridiidæ* that, in many parts of the world, periodically swarm and migrate, either in the adult form by flight, or in the earlier wingless stage on foot. The female Acridiid lays her eggs in inspissated masses in holes dug in the soil by the hardened end of her abdomen.

Family *Locustidæ* (Lat. *locusta* = a locust): Long-antenna Grasshoppers. It must be remembered that the destructive migratory "locusts" do not belong to this family, the members of which though in the main herbivorous are not exclusively so. In the *Locustidæ* the antennæ are extremely long and slender, consisting of many more than 30 segments; the tarsi are composed of 4 distinct segments; and the female usually possesses a long, sabre-shaped ovipositor. The auditory drums when present (or the chinks that lead to them) are to be found in the tibiæ of the front pair of legs. The trilling of these grasshoppers is made by rubbing the bases of the tegmina, or front wings, together, one tegmen having a file of teeth on its inner surface, the other having its inner margin sharpened to act as a scraper. It is usually only the male that is musical. Dr R. Howard brought to the London School of Tropical Medicine, from an island in Lake Nyassa, a specimen of *Enyaliopsis petersii*, one of the ugly wingless species of *Locustidæ*, stating that it has the reputation of either giving a bite or exuding a fluid that causes extensive superficial inflammation and vesication.

Family *Gryllidæ* (Lat. *gryllus* = a cricket): Crickets. The species of this family are dingy-coloured insects with tegmina, or anterior wings, closely fitted to the back and sides of the body. The antennæ are generally long and slender; the tarsi usually have 3 segments, but sometimes 2 or 4; and the female usually possesses a long awl-shaped ovipositor. The auditory drums, and the chirping mechanism of the male, agree with those of the *Locustidæ*. The anal cerci are long and unsegmented, and often the tips of the wings are rolled up, and project beyond the body like an additional pair of cerci.

Order ISOPTERA: Termites.

(Gr. ἴσος = equal, or alike, and πτερόν = wing.)

This order includes the single family of *Termitidæ*, or so-called "white ants," which by some authors are with good reason ranked with the *Orthoptera*. Though, on account of their social organisation, they are persistently called "ants," they have—beyond their common ties as insects—no connection with the true ants: in this Age of Education they should be referred to as Termites.

The termites are soft-bodied social insects which may, or may not, have caducous wings, both pairs of wings, when present, being of equal size, membranous, and much longer than the body. All 3 segments of the thorax are distinct, and the abdomen consists of 10 segments, and ends in a pair of small cerci. Metamorphosis is "incomplete."

Termites live in organised polities, or "colonies," which are lodged either in mound-like nests coated with hardened clay, or in clay-lined passages ("galleries") tunnelled in or on dead trees, stumps, and the woodwork of houses, in warm countries. They do not, in the ordinary way of life, leave home, but work under cover and in darkness; although there is one South African species, the workers of which have eyes, and come out into the daylight. In some parts of the world the colonies are enormously prolific, and their mounds are so large and so extensive as to resemble native villages.

The multitude of the full-grown individuals of a typical termite-polity are blind, wingless forms (male and female) in a state of arrested sexual development, and are known as *workers*. Besides these ordinary workers the population includes (1) a considerable number of workers with enormous heads, known as *soldiers*, and (2) a pair—or, perhaps, sometimes more than one pair—of sexually developed individuals male and female, known as *king* and *queen*, which are the parents of the colony. The queen, at least, is lodged in a special chamber, where she is attended by workers and becomes a mere stationary engine for producing eggs: she may live for years, and her abdomen becomes enormously distended until it has something the appearance of a fair-sized potato.

Besides workers and soldiers and the royal parents, the colony also contains a great number of *larvæ* in all stages of development—the issue of the queen. Many of these, of course, are destined to become workers and soldiers; but a great number of them develop into sexually mature *winged males* and *females*, and these periodically leave the colony in prodigious streams. In India the flights usually occur about sunset, in the early part of the rainy season. The great majority of these winged individuals perish at once, being devoured by the multitude of birds and bats that are waiting on them. As to those that do not immediately perish, beyond the fact that they soon alight and cast their wings, the fate is problematical. Some are devoured by lizards, etc. Some, it is said, may, if they happen to fall near their own parent colony, be captured by wandering workers and be carried off forthwith to become royalties in a new colony, or even in the colony which they have just left. It is also said that males and females may couple and may form the nuclei of new colonies without any assistance from chance workers, and it is only reasonable to suppose that, in nature, new colonies must sometimes originate in this way. In the case of a common Calcutta species I have several times taken a coupled pair and have kept them in suitable surroundings, but have never succeeded in raising the beginnings of a colony from them, though this has been done by another observer elsewhere, and has, on the other hand, been scouted as an impossibility by Fritz Müller.

With some species of termites there occur other castes of sexually arrested individuals, in addition to ordinary workers and ordinary soldiers; and in some cases a certain number of larvæ are kept in such a condition that by appropriate treatment (probably by special feeding) their reproductive organs may develop if anything should befall the royal parents. Such larvæ while still in the potential stage are known as *reserve royalties*, and when they become functional, as *substitution royalties.*

Termites keep their nests and galleries very clean; the cast skins and the dead are eaten; even the excrement is made use of, being eaten until its nutriment is exhausted and then worked into plaster for the galleries. The young

termites are at first fed on saliva, afterwards on regurgitated food or on excrement that is still nutritious. Many different kinds of insects live as commensals in termite colonies.

The ravages of termites in tropical countries are notorious, everything in the form of wood or vegetable fibre is eaten, and large beams of timber may be demolished unnoticed, only a deceptive "shell" being left. The entire woodwork of a house may be destroyed, and unprotected railway-sleepers may be honeycombed as soon as they are laid. On the other hand, in the general economy of tropical nature these insects play a necessary part in bringing dead timber back into the living stream of energy.

In out-of-the-way places a medical officer is sure to be consulted as to the protection of buildings, etc., from the attacks of termites. Certain kinds of timber are distasteful to termites: in India, sál and teak have this reputation: in my old house in Calcutta there were beams of sál that must have stood for nearly a century, and beams of teak that had been in place for scores of years, and although there were plenty of termites in the walls, and the ends of a few of the beams had at different times been sampled by them, I hardly remember any instance of a beam showing evidence of an attack that had been at all sustained. Probably other kinds of equally hard, dense, aromatic wood are equally resistant. One of the cheapest and most effective deterrents is petroleum residue ("blue oil"), applied without stint. For buried timber, tarring, or impregnation with a strong solution of the cheaper metallic salts (*e.g.* mercury and copper), or even superficial charring, may be recommended.

A fine account by Smeathman of one of the African species of termites is to be found in the *Philosophical Transactions of the Royal Society for* 1781, vol. lxxi., pp. 60-85. Smeathman states that from the periodical swarms of winged males and females that leave the nest, future kings and queens are captured by casual workers and "are elected kings and queens of new states."

Order EMBIIDA.

This order includes one small family of small insects—the *Embiidæ*—which somewhat resemble a slender termite and are sometimes included

in the same order with the termites, or with the *Orthoptera*. The wings, when they are present, are like those of termites in form and in being all alike, but they are not caducous, and they have a peculiar imperfect venation. The species are found in sheltered places, under stones, on bark, in wood and thatch, etc., and they spin webs for protection.

Order CORRODENTIA: Book-lice.

(Lat. *corrodere* = to gnaw.)

This order stands for a single family, the *Psocidæ* (? Gr. ψῶχος = dust), which are sometimes included in the *Isoptera* and sometimes in the *Orthoptera*.

Book-lice (Fig. 115) are soft-bodied, and for the most part exceedingly minute insects, so named because certain

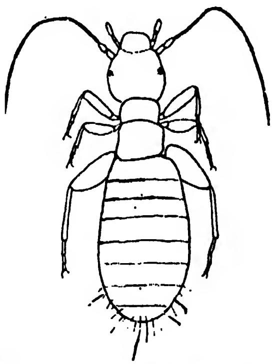

FIG. 115.—"Book-louse," from dried fish.

species are commonly found in old books, eating the binding. They are also frequent pests of entomological collections, feeding not only upon the lining of the trays but also upon the specimens, and they will sometimes attack dried provisions.

The head and eyes are (relatively) large, and the antennæ are long and very slender: the mouth-parts are formed for biting. The thorax usually appears to consist of 2 segments. Metamorphosis incomplete. In the winged species both pairs of wings are membranous, the anterior pair being the larger, and the veins are sinuous and prominent, the cross-veins being few.

Many Psocids live in moss, lichen, the bark of trees, etc.,

and some of these protect themselves and their eggs with a web. Books can be protected from book-lice by painting with a spirit solution of perchloride of mercury; creasote will protect entomological collections.

Order THYSANURA: Bristle-tails.

(Gr. θύσανος = tassel, and οὐρά = tail.)

In the zoological scheme this order is placed, along with the next order, *Collembola*, at the bottom of the Class Insecta. The members of both orders are small, wingless insects, and some of them seem to have rather close affinities with some of the Myriapoda.

The order is named from the two or more long antenna-like filaments that project from the last abdominal segment.

The Thysanura are fragile, wingless insects of no great size, and they do not undergo a metamorphosis: the antennæ are long and are composed of a multitude of segments, and the abdomen consists of 10 visible segments. They are common in damp and dark places, particularly in the tropics. The Silver fish-insect, *Lepisma*, is a good example of the order—an active little insect, covered with silvery scales, which hides among books and papers: a common Calcutta species of *Lepisma* certainly feeds on these things, and also on cloth.

Order COLLEMBOLA: Springtails.

(Gr. κόλλα = glue, and ἔμβολος = a peg.)

The insects of this order are named from the coarse tube which projects from the ventral surface of the 1st abdominal segment, and is supposed to be adhesive. Their popular name of Springtails is derived from the existence, in many of them, of a pair of long, stiff filaments, placed near the end of the body and flexed under the abdomen—the sudden extension of which produces a jump.

The order includes minute, wingless insects which do not go through any metamorphosis. The antennæ have few (4 to 6) segments, and the legs have no tarsus. Springtails are found in damp places on land, and some are aquatic both in fresh water and in the sea. They are said to be common on snow, and uncommon in dry and hot regions.

We have now done with all those orders of insects that include species which the medical officer is justified in regard-

ing as detrimental to health, and with certain related orders that may be classed as inert; but we have still to notice several orders that include species, *outside any of the foregoing orders*, which, in any or every active stage of their existence, are predaceous upon other kinds of insects.

No doubt predaceous insects deal impartial damage to friend and foe, and the view, sometimes strongly advocated, that they are all tried friends, to be grappled to the medical officer's soul with hooks of steel, is somewhat optimistic.

CHAPTER XXII

Stone-flies, May-flies, Dragon-flies, Ant-lions, Scorpion-flies, Caddis-flies

Order PLECOPTERA: Stone-flies.

(Gr. πλέκος = plaited, and πτερόν = wing.)

A SMALL order, containing only one family, *Perlidæ*, closely related to the *Orthoptera*. The larvæ are aquatic, and metamorphosis is "incomplete."

The body is Orthoptera-like: all 3 thoracic segments are distinct; the abdomen is composed of 10 segments and

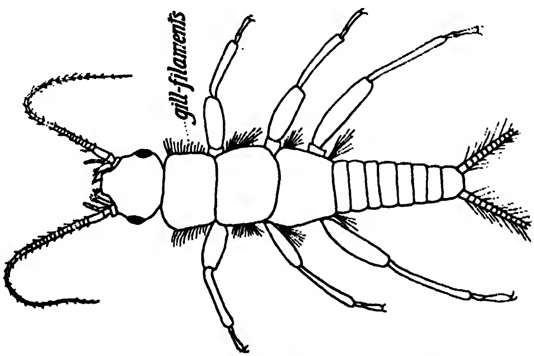

FIG. 116.—Young aquatic Larva of *Perlid*, enlarged.

usually ends in a pair of long, jointed cerci; the antennæ are long, slender, and many-jointed: the hind wings are much larger than the front wings, and fold like a fan; but the front wings are membranous, not stiff like those of Orthoptera. When the wings are folded the front wings lie one above the other, so that only one of them is seen. The mouth-parts

are of the biting kind, but are weak, sometimes even membranous. The coxæ are small, and wide apart.

The eggs are extremely numerous and are shed in water. The larva (Fig. 116) much resembles the adult, except for the absence of wings and for the presence, in many cases, of three pairs of filamentous gill-tufts, one tuft behind the base of each leg. The larvæ are usually found in rapid-flowing water, under stones, and they are carnivorous; from their usual situation they are not to be regarded as at all common enemies of mosquito-larvæ, though the question whether they may be inimical to *Simulium* larvæ, which also live in coursing water, deserves attention. In an aquarium—where of course the larva of *Simulium* is rather impotent—Perlid larvæ certainly feed on *Simulium* larvæ.

Order EPHEMERIDA: May-flies.

(Gr. ἐφήμερος = living but a day.)

This order contains a single family, the *Ephemeridæ*—delicate insects that in the adult winged phase exist but a few hours, a day or two at the utmost; but which have, as aquatic larvæ, a life of considerable duration.

The adult Ephemerid has filmy net-veined wings, of which the hind pair are very much smaller than the front pair, or may even be absent. The eyes are large, especially in the male, in which sex, in some species, each eye may be divided into two distinct organs. The antennæ are short, and are composed of 1 or 2 stoutish segments and a slender style. The mouth-parts are vestigial and functionless, since the transient existence is devoted entirely to reproduction, and no food is taken; but the digestive tube is present and, being filled with air, acts as a balloon. The mesothorax, as in other insects of sustained flight, is the chief component of the thorax. The front pair of legs are particularly long, especially in the male. The abdomen consists of 10 segments, and ends in two or three extremely long filamentous cerci, which at sight distinguishes these insects from midges. The adult Ephemerid shortly after it has flitted from its pupal tube casts its skin, even the skin covering the wings,

and is the only insect that is known to moult after reaching sexual maturity.

The eggs are numerous, and are shed into water. The larva (Fig. 117) has long, filamentous or feathery anal cerci, and soon develops numerous tracheal gills on the sides of some of the abdominal segments; these gills are commonly broad leaves, but are sometimes feathery, and are sometimes protected by a special cover. The larvæ are found in water of all kinds; some swim actively by means of their long feathery caudal filaments, others adhere to stones, and others burrow in the mud. Some of the free-swimming forms are

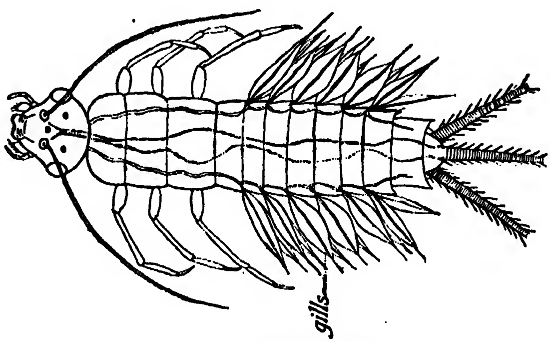

FIG. 117.—Larva of a May-fly.

carnivorous, and have been proved by experimental observation to be destructive to mosquito-larvæ.

May-flies, at certain seasons and in the evening, occur in myriads together. An illuminated house-boat in a tropical delta is the place to learn what a swarm of may-flies can be like: they will fill the boat if the lights are not put out.

Order ODONATA: Dragon-flies.
(Lat. *odonatus* = with buskins of felt.)

Dragon-flies are of interest for us, since both as adults and in the aquatic larval stage they are highly voracious of other insects, and the aquatic larvæ of one large group of dragon-flies—the *Agrioninæ* (Fig. 118)—are among the most active enemies of mosquito-larvæ.

The order includes two families of insects having an

elongate body, an extremely mobile head, large eyes, inconspicuous antennæ, and four long, rather narrow, stiff, transparent, net-veined wings of nearly equal size. Metamorphosis is "incomplete," though the aquatic larva and nymph are a good deal unlike the adult.

The mouth-parts are well formed for biting. The wings are peculiar in being set back well clear of the legs, and in having a sort of flaw, or *nodus*, near the middle of the front edge. The legs, as a rule, are short and slender, and are closely fringed or felted with fine spinules; they are hardly used for progression, the insect being above everything aerial.

The eggs are laid in or near water in which the larva is hatched. The larva has a most curious hinged, prehensile, and usually elongated labium, known as the *mask*, which in

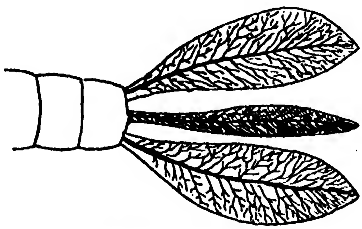

FIG. 118.—Tracheal Gills of Agrionid Larva.

repose is shut back like a carriage-step and in action shot out like an arm to capture living prey. The typical dragon-fly larva breathes chiefly by the rectum, which is furnished with tracheal papillæ, or with distinct tracheal gills: water is inhaled into the rectum, and after use is expelled with sufficient force to propel the animal forwards; or the rectum with its gills may be rhythmically protruded into the water. In one group of dragon-flies—the *Agrioninæ*—the larva has three very large tracheal gills at the end of the abdomen; these also act as a powerful fin. The larvæ are found in the same places as mosquito-larvæ, and the actively swimming *Agrioninæ* devour the latter freely.

The advanced larva, or "nymph," often has a broad, squat abdomen, quite unlike that of the adult.

Dragon-flies are usually to be seen hawking flies and other insects about ponds and streams, or in damp places.

There are two families in this order, namely, (1) the *Libellulidæ*, or dragon-flies proper, in which the hind wings are slightly larger than the front wings, and the wings in repose lie horizontal and more or less extended; and (2) the *Agrionidæ*, or demoiselle-flies, in which the hind wings are the same size as, or slightly smaller than, the front wings, and the wings in repose are laid backwards and lie vertically.

Order NEUROPTERA.

(Gr. *νεῦρον*=a fibre or nerve, in allusion to the great number of nervures, or veins, in the wings, and *πτερόν* =wing).

The *Neuroptera* include the Alder-flies, Snake-flies, Ant-lions, Mantis-flies (which are not to be confused with the Praying Mantids), Aphis-lions or Lacewings, and several other families that have no vernacular names. Some of the latter resemble dragon-flies, from which, however, they can

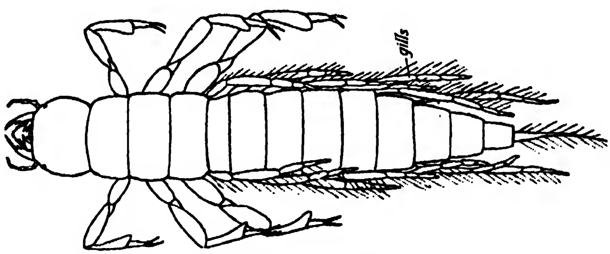

FIG. 119.—Larva of an Alder-fly.

be distinguished by their longer antennæ and by the wings not having the break (*nodus*) in the front margin.

In this order the mouth-parts are formed for biting, and both adult and larva are rapacious; there are two pairs of transparent net-veined wings of equal size, or the posterior pair slightly the smaller; the antennæ are conspicuous; and the metamorphosis is "complete."

The Alder-flies (*Sialidæ*) and the Snake-flies (*Rhiphidiidæ*) are almost restricted to the northern hemisphere. In both families the wings in repose lie sloping over the body, as in moths, and their veins are not so numerous as to form a fine lacework; and the antennæ are long and slender. The

males of some of the alder-flies have enormous mandibles. In the snake-flies the prothorax and back part of the head are elongated to form a long "neck," and the female has a long ovipositor. The larva of the alder-flies is aquatic, and most of the abdominal segments carry a pair of segmented, fringed gill-filaments (Fig. 119); it returns to land to pupate.

The Ant-lion flies (*Myrmeleonidæ*) are not unlike dragon-flies, but the antennæ though short are conspicuous and clubbed, and the hind wings are decidedly smaller than the front wings. The larvæ are known as ant-lions: they have enormous mandibles, which are grooved and so adapted to the maxillæ as to form tubes; they dig beautifully symmetrical pitfalls in dry soil, at the bottom of which they lie concealed, to seize and suck dry with their powerful grooved mandibles any unwary insect that may fall in.

The *Ascalaphidæ* also are like dragon-flies, but are distinguished by their long antennæ ending in a knob. The larvæ are quite like ant-lions, but do not make pitfalls.

The *Nemopteridæ* are recognised by their extremely long, narrow, oar-shaped or racquet-shaped hind wings. Their larvæ are like ant-lions, but have a neck of extraordinary length.

The Mantis-flies (*Mantispidæ*) resemble small mantises, having the same elongate prothorax and the same raptorial fore legs for striking and grasping insect prey; but they may be distinguished by the wings, which are subequal in size and alike in consistence—the hind wings also not folding like a fan in repose. The eggs of *Mantispidæ* are stalked.

The Lacewings or Aphis-lions (*Chrysopidæ*) are delicate insects with long antennæ, four filmy net-veined wings, and (in life) shining golden eyes. The eggs are attached to leaves, etc., by very long stalks. The larva has enormous mandibles like an ant-lion, and feeds on aphids.

The *Coniopterygidæ* are tiny Neuroptera somewhat resembling the males of some of the bark-lice (*Coccidæ*) upon which they feed. The wings are not net-veined, and the posterior pair are extremely small.

So far as one can see behind the veil, the order *Neuroptera* is directly beneficial to man, though it is not known that any particular Neuropteron is hostile to any specific pathopoeic insect.

Order MECOPTERA: Scorpion-flies.

(Gr. μῆκος = length, and πτερόν = wing.)

A small order of insects, consisting of one small family—*Panorpidæ*—closely related to the *Neuroptera*.

The head is produced downwards into a long, stout beak, which bears the mandibles at its tip. The antennæ are long and slender. There are usually two pairs of long, rather narrow, membranous wings, which have numerous long veins but only a moderate number of cross-veins; some species are wingless. In the males of *Panorpa* the terminal segments of the abdomen are narrowed and are carried aloft aggressively like the "tail" of the scorpion. The larva has ordinary biting mouth-parts, true segmented legs on the thoracic segments, and stumpy legs (pseudopods) on most of the abdominal segments. Both adult and larva are carnivorous.

Order TRICHOPTERA: Caddis-flies.

(Gr. θρίξ, τριχός = hair, and πτερόν = wing.)

Moth-like insects, very closely related to Moths (*Lepidoptera*), found near water. There are two pairs of wings, which are covered with fine hair, the hind pair being the larger. The mouth-parts have the form of a short sucking-tube which is formed by the labrum, labium, and maxillæ; the maxillary and labial palps are conspicuous. The antennæ are thread-like and are sometimes very long.

The larvæ, known as caddis-worms, are aquatic, and commonly live in portable tubes of their own construction: these are made of all sorts of stuff, cemented together by silky threads—usually of bits of grass, or stick, and dead leaf, sometimes of small stones, shells, or grains of sand; they are generally open at both ends, so that currents of water for breathing may pass through, breathing being usually carried on by lateral abdominal gill-filaments. Caddis-worms are found in water of all kinds: most of them are herbivorous, but some of those that live in rapid streams are carnivorous; these last construct fixed retreats and spin webs for snaring their prey, which may consist among other things, of the larvæ of *Simulium*.

CHAPTER XXIII

The Class Arachnida, and the Order Acarina

THE Arachnida (αράχνης = a spider) are a much more diversified group than the Insects, and from the strictly medical standpoint are considerably less important. They differ from all other Arthropoda in not having antennæ.

Some Arachnida live in the sea or in fresh water, and some of these aquatic forms breathe by gills; but the majority of the Class are terrestrial and breathe air direct, sometimes by tracheæ of a sort, sometimes by the general surface of the body, and in the case of many of the larger forms by structures known as "lung-books"—structures resembling "dry" gills, which are enclosed in pockets that open on the ventral surface of the abdomen.

In some Arachnida, for instance the Mites and Ticks, the segmentation of the body is obliterated; but in the typical members of the Class the segments, or many of them, are distinct, and are grouped in two regions, namely, a cephalothorax that carries the true appendages, and an abdomen that either has no appendages at all, or has appendages that have been modified out of ordinary recognition.

The true appendages are never more than six pairs. The first pair, or *chelicerœ*, lie in front of the mouth, and the second pair, or *pedipalps*, are placed one on either side of the mouth. Both the cheliceræ and the pedipalps show much diversity of form. The remaining appendages—usually four pairs, but in the gall-mites only two pairs—are legs for locomotion.

Eyes when present are always simple, and vary in number from two to twelve.

The mouth is a chink, since most Arachnida live on the juices of animals or plants. In some forms the bases of some

of the legs are modified to act as "jaws" for helping to squash prey, or for closing the vestibule of the mouth. The alimentary canal is not convoluted, but the digestive and absorbent surface is increased by numerous paired diverticula, or gastric pouches. The anus is ventral and subterminal. In the terrestrial Arachnida excretory Malpighian tubules open into the hinder part of the gut as in insects, but additional excretory glands opening on the coxæ of the legs may also be present.

Some Arachnida are viviparous, but the majority lay eggs. The reproductive organs usually open ventrally at the anterior end of the abdomen. As a rule the young resembles the parents, but in the ticks and their kind the young differs from the adult in having only three pairs of legs, and does not acquire the fourth pair until after the first moult.

Existing Arachnida are grouped in the following eleven Orders, only four of which, namely, the *Acarina*, *Scorpionidea*, *Araneida*, and *Solifugæ*, need be further considered.

Order 1: *Pycnogonida.* Marine Arachnida with a slight superficial resemblance to Spiders without an abdomen. They are found at all depths, from the tide-marks to the abysses of the ocean.

Order 2: *Xiphosura*, or King-crabs. Large marine Arachnida with the cephalothorax enclosed in a horseshoe-shaped carapace, a roughly pentagonal abdomen carrying leaf-like appendages to which the gill-books are attached, and a long post-anal spine. They are found in muddy shoal water on the Atlantic coast of America and on the shores of Southern and South-eastern Asia.

Order 3: *Scorpionidea*, p. 294.

Order 4: *Pedipalpi.* Arachnida which have a general resemblance to Scorpions, but differ in having the pedipalps not chelate, or only imperfectly so, the first pair of legs antenna-like, the post-abdomen or "tail" either very much attenuated or altogether absent, and no post-anal spine. They are predaceous, chiefly on insects, and are found in the Oriental, Ethiopian, and Neotropical regions.

Order 5: *Araneida;* Spiders, p. 298.

Order 6: *Palpigradi.* Minute Arachnida with some resemblance to tiny spiders, but differing, *inter alia*, in having

an elongate 11-segmented abdomen, ending in a long, segmented, filiform "tail."

Order 7: *Solifugæ*, p. 300.

Order 8: *Pseudoscorpionidea;* Book-scorpions. Small Arachnida resembling small scorpions without a "tail." They live under bark, stones, etc., and are sometimes found in houses. They are predaceous on small insects.

Order 9: *Phalangidea*, or *Opiliones*. Arachnida that resemble and are commonly mistaken for very long-legged spiders; but differing from spiders in having the abdomen (which is segmented) broadly united to the cephalothorax, and the chelicerae chelate.

Order 10: *Acarina;* Mites and Ticks.

Order 11: *Tardigrada;* Bear-animalcules. Minute aberrant Arachnida that, when they are noticed at all, are mistaken for mites. The only appendages are four pairs of stumpy, unsegmented legs. They are found among herbage, and under flower-pots, etc., in gardens.

From the medical standpoint the only Order of outstanding interest is the *Acarina*, which will therefore be taken first.

Order ACARINA: Mites and Ticks.

(Gr. ἄκαρι = a mite or tick.)

The members of this large Order are for the most part minute; many of them are parasitic on animals and plants; many are predaceous on their own kind. Except in one small family—the *Opiliocaridæ*—which is doubtfully included in the Order, the body is not visibly segmented, but is commonly a roundish or oval mass, sometimes without any distinction even of regions, but sometimes showing a more or less perfect division of cephalothorax and abdomen. In one group the body is elongate and almost worm-like. The anterior end of the body usually forms with the chelicerae a sort of beak or *rostrum*.

The appendages exhibit a good deal of diversity, and in one family (gall-mites) the legs are reduced to two pairs. The *chelicerae* are sometimes needle-like, more often chelate or pincer-like, and sometimes grapnel-like; they are usually used for piercing; and when they are pincer-like

and used for grasping small prey, they may be remarkably exsertile.

The mouth is generally a chink, deep-seated at the base of the cheliceræ; sometimes the bases of the pedipalps are united to form a lip. In addition to the cheliceræ other mouth-structures may exist—in particular a needle-like or rasp-like "tongue," or *hypostome*, formed by a prolongation of the ventral edge of the "beak" aforesaid. The pharynx is suctorial, since mites live chiefly on juices, and the capacity of the stomach is generally increased by paired gastric cæca. The Malpighian tubules, when present, open into the hind part of the intestine, near the anus; sometimes there is no open connection between this part of the intestine and the stomach.

When special breathing-organs are present they have the form of tracheæ, and the manner in which these open is used for classifying mites.

The genitalia open ventrally, sometimes between the last pair of legs, or (as in ticks and their kind) near the front end of the body, or at the after end of the body. The female produces eggs, generally in great number, and the larva usually differs from the parents in having only three pairs of legs; after moulting, the larva becomes a *nymph* with four pairs of legs, but still sexually immature; and after another moult the nymph is transformed into the adult. This series of metamorphoses may be gone through directly and quickly, or may be strangely modified and arrested, or may—as in many ticks—occupy several months if circumstances are adverse.

This Order is one of very great importance to the medical officer. Many of the species are troublesome ectoparasites of domestic animals and man; others live entirely on the blood of vertebrates (including man), and incubate and disseminate various Hæmatozoa dangerous to their hosts; others do indiscriminate damage to man's stored provisions; and others, again, may work havoc with his growing crops.

The distinctions between the more important families of *Acarina* are shown in the following table. The families that chiefly concern the medical officer are the *Ixodidæ*, *Sarcoptidæ*, and *Tyroglyphidæ;* the *Trombidiidæ* and *Tarsonemidæ*, and perhaps also the *Gamasidæ* occupy points on the medical

horizon; but the other families are of no importance, further than that some of them include numerous species which are predaceous on other mites.

Synopsis of Principal Families of Acarina.

(Based mainly on Banks.)

A. Body not vermiform, always with four pairs of legs in adult = 1.
B. Body vermiform, with four or two pairs of legs = 2.

1. { Abdomen composed of 10 distinct segments, each of the first 4 with a pair of dorsal spiracles (stigmata) *Opiliocaridæ.*
Abdomen not segmented = 3.

3. { Two pairs of stigmata, one above the third pair of legs, the other placed quite dorsally above the fourth pair of legs *Holothyreidæ.*
A pair of stigmata, placed one on either side behind the coxæ of the fourth, third, or second legs = 4.
No stigmata in the positions aforesaid = 5.

4. { Cheliceræ ending in a series of strong, laterally-directed, hook-like teeth *Ixodidæ.*
Cheliceræ not ending in hooks, usually pincer-like and exsertile = 6.

6. { Stigmata behind the third pair of legs *Gamasidæ.*
Stigmata behind the second pair of legs; the nymphs attach themselves to insects by means of a long viscid stalk secreted by adanal glands *Uropodidæ.*

5. { A pair of (usually club-shaped) bristles, projecting each from a pore, or *pseudostigma*, placed near each posterior corner of the cephalothorax; stigmata concealed in the leg-sockets; integument hard and shiny = *Oribatidæ.*
No pseudostigma and bristle in this position; integument softer = 7.

7. { Aquatic mites (fresh water and marine) = 8.
Not fitted for an aquatic life = 9.

8. { A large movable beak or head. Marine *Halacaridæ.*
Beak small; legs fringed with hairs for swimming; mostly fresh water *Hydrachnidæ.*

9. { Pedipalps usually of 4 or 5 segments; the tarsi usually end in claws, never in a sucker; stigmata (when present) near bases of cheliceræ = 10.
Pedipalps of 3 segments, more or less adherent to lip; the two anterior and two posterior pairs widely separated; the tarsi, or some of them, usually end in a sucker; no special breathing organs as a rule = 11.

10. { Pedipalps with an additional, subterminal finger-like appendix (Fig. 127) *Trombidiidæ.*
Pedipalps with simple tip *Bdellidæ.*

11. Pedipalps minute, hardly visible; chelicerae styliform; female only with a pair of spiracles in front of the anterior legs, and with a pseudostigma and club-shaped bristle on each side just behind the anterior legs *Tarsonemidæ*.
Pedipalps small but distinct; chelicerae generally pincer-like; no special breathing-organs; female without pseudostigmatic club = 12.

12. Integument generally with fine parallel striæ; legs short; parasitic *Sarcoptidæ*.
Integument not striated; legs longer; not as a rule parasitic *Tyroglyphidæ*.

2. Four pairs of legs; parasitic in sebaceous glands of mammals *Demodicidæ*.
Two pairs of legs; parasitic on vegetation *Eriophyidæ*.

CHAPTER XXIV

Order Acarina (*continued*): The Ticks

Family IXODIDÆ: Ticks.

THE species of this family are in all stages of their existence blood-sucking parasites of vertebrate animals; and, as with so many other blood-suckers, the evil that they do is not confined to mere robbery of blood, but lives after them in the form of zymotic contamination of their victims.

In the *Ixodidæ* the body is more or less oval, with the segmentation and even the distinction between cephalothorax and abdomen obliterated, though in one genus (*Ornithodorus*) a notch on either side behind the last pair of legs just suggests a division into these two regions. At or near the front end is a movable "beak," or *capitulum*, which consists of a strongly chitinised basal piece—the *basis capituli*—surmounted by the pedipalps, chelicerae, and other mouth-parts.

The basis capituli is a flattened ring, which encircles the bases of the chelicerae; the pedipalps are broadly implanted in its sides; dorsally its cuticle is produced over the chelicerae to form a laterally inflexed cover, or "sheath" for each of them; ventrally it is prolonged in the middle line to form a spatulate rasp—the *hypostome*.

Each chelicera (Fig. 120) consists of a long shaft, to the distal end of which are hinged, side by side, two stoutly uncinate cusps, which can be moved laterally so as both to cut and to make fast in the skin of a victim. The shaft and a considerable portion of the "hooks" are invested in a sheath formed by the prolongation of the dorsal cuticle of the basis capituli, the sheath being closely beset with rows of microscopic barbules.

The hypostome (Fig. 120), which lies ventral to the chelicerae and is a prolongation of the ventral lip of the basis capituli, is armed on its ventral surface with files of strong recurved teeth; it aids the chelicerae in boring through the skin of the victim and making good the hold.

The pedipalps form an adjustable sheath to the more delicate mouth-parts just described, and are frequently hollowed along their inner surface for this purpose; when the mouth-parts are in action the pedipalps are, as a rule, bent aside.

The integument may be hard, or merely tough, or may

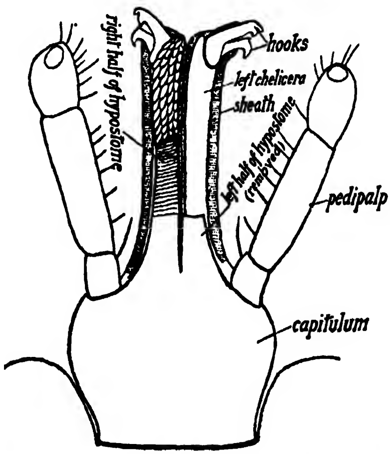

FIG. 120.—Rostrum of a Tick; left half of hypostome removed.

be comparatively soft with localised chitinous indurations; embedded in it there are small glands, whose secretion is possibly acrid and defensive, and sparse hairs.

On the ventral surface of the body the four pairs of legs are attached by broadly sessile coxae. Each leg consists of 6 segments (including the coxa), of which the last, or tarsus, is as a rule incompletely subdivided into two pieces, as also may be the 3rd segment, or femur; the tarsus ends in a pair of claws, which are borne on a slender stalk, with in some cases a membranous plate, or *pulvillus*, between them. In the cuticle of the extensor border of the tarsus of the first pair of legs there exists a narrow-mouthed pit lined with sensory hairs; this, which is known as Haller's organ, was

supposed by its discoverer to be an organ of hearing, but is considered by Nuttall to be olfactory.

The genital pore in both sexes is situated in the middle line, on the ventral surface, not far behind the capitulum. Far behind it, in the same line, lies the opening of the rectum. The spiracles are placed on conspicuous stigmata which lie behind and dorsad of the coxæ of the fourth, or the third pair of legs.

The mouth is deeply seated between the cheliceræ and the hypostome; the pharynx is suctorial and leads by a slender gullet to a large stomach, the capacity of which is increased by paired caecal loops; these are nicely seen in a well-preserved male tick, cleared and mounted in balsam. The salivary glands, which are loosely racemose with long tubules, are large; they extend through nearly the whole length of the body on either side, and open near the base of the hypostome; their secretion is supposed to be hæmolytic, and in some cases, from its irritant effects, to be poisonous.

The excretory organs consist of two long Malpighian tubules, which open into the isolated hind part of the gut, and of *coxal glands* which open on the coxæ.

The male tick is smaller than the female, and is often conspicuously different in other respects. In fertilisation, which may be effected while the female is attached, the male inserts the spermatophores with the mouth-parts. The eggs are laid in an inspissated mass on the ground, oviposition being a prolonged affair, hundreds or even thousands of eggs being extruded with great deliberation. According to Neumann the entire parturition is completed, in the *Ixodinæ*, in ten to thirty days. In some cases (*Ixodinæ*) the spent female dies at once; in other cases (*Argantinæ*) she does not. The term of incubation depends upon temperature, and according to Neumann lasts from fifteen to forty days.

The larva differs from the adult in having only three pairs of legs, no stigmata, and of course no genital pore. Much yolk is occluded in its gut, on which provision it can exist for several months without other nutriment. The larvæ hang about in grass and herbage on the wait for a host (mammal, bird, or reptile) to which they can affix themselves. After imbibing blood for some days the larva, as a rule, drops from

its host to the ground again, to continue its growth, and in course of time—two weeks to several months, according to temperature—moults into a nymph.

The nymph resembles the adult in having four pairs of legs and a pair of stigmata, but it has no genital pore. It waits about, in grass and herbage, until an opportune host appears, to which it attaches itself. After satiation it, as a rule, drops to the ground again, and in course of time—some weeks or months, according to temperature—moults into the adult form.

In a few species (the notorious *Boophilus* furnishes a good example) the larva, when it has once found a host, completes its development and attains the adult stage on that individual host. In this case, of course, development is uninterrupted and much less precarious, and is therefore much quicker.

Some ticks (*Ixodinæ*) are, in natural circumstances, short-lived, the male dying after copulation and the female after parturition; others (*Argantinæ*) are comparatively long-lived, the female producing batches of eggs periodically. But even the *Ixodinæ* are tenacious if the normal tenour of their life is checked; several observers have kept them alive, unfed, for three or four months, and Nuttall kept starved specimens of *Hæmaphysallis* alive for seven months.

Ticks may be grouped in two subfamilies—*Ixodinæ* and *Argantinæ*—which some authors prefer to regard as distinct families. In the *Ixodinæ* the rostrum or capitulum is terminal in all stages of existence; in the *Argantinæ* it is inferior in the adult and subterminal only in the early larval stage.

Subfamily IXODINÆ: Hard Ticks.

In this subfamily more or less of the dorsum of the body is protected by a chitinous shield, or *scutum*, and in the males of some species there are chitinous plates on the ventral surface also. The capitulum is altogether anterior, being implanted in the front end of the body. Frequently the posterior border of the body is regularly cut into fine festoons, which are particularly distinct in the male. The stigmata are large, and lie behind the coxæ of the fourth pair

of legs. Eyes, when present, are situated on the edge of the scutum. The pedipalps, which are rigid and form a distinct sheath for the mouth-parts, have the 4th segment sessile and vestigial, so that they appear to consist of only 3 segments. In the legs the coxæ are generally armed with tubercles or spurs, and the tarsi carry a pulvillus as well as a pair of claws.

There are certain constant grooves on the body of a hard tick. Of particular importance, from the taxonomic standpoint, is the *anal groove*—a fine groove, usually in the form of a semicircle with the concavity forwards, that half encircles the anus. This groove is absent in a few forms.

The female Ixodine differs from the male not only in being much larger and more distensible, so that in some species when she is gorged she is as large and rotund as a large filbert; but also in having a small scutum, which covers only the front end of the body—instead of covering the whole dorsum, as it does in the male; and further in the presence on the dorsum of the basis capituli of two round or oval glandular depressions known as *areæ porosæ.*

The larva and nymph of the Ixodinæ, whether prospective female or male, resemble the female in having a small scutum. The Ixodinæ are fixed parasites, the adult attaching itself permanently to its host. When the female is fertilised and gorged, and has matured her eggs, she drops from her host, delivers her eggs, and forthwith dies.

The "hosts," or victims, of Ixodinæ include land-vertebrates of all kinds; but man is not often attacked by adult Ixodines, though the larvæ will readily burrow into his skin if they get a chance. One species of *Dermatocentor* is said to carry the Piroplasma of Rocky Mountain Spotted Fever in man; but with this exception Ixodinæ are of no particular importance in human pathology, though when they do bite man the consequences may be unpleasant.

It is among domestic animals that the Ixodinæ work havoc; not merely by abstraction of blood, though even in this way, if they attack a young or weakly animal in force, they may do mortal damage; but by spreading among them the infections of certain destructive diseases due to specific piroplasms and spirochætes. As in the normal course of things a given tick in any one stage of its existence feeds only on a single host, if it should become infected from that host it will not have any opportunity of passing on the infection directly, but the infection remains

latent and becomes active in some subsequent stage of the tick's existence or in some subsequent generation. In some cases a female tick thus infected transmits the infection to her eggs, so that in due time the larvæ from these eggs are infective. In this way one of the worst and commonest of the cattle-fevers due to piroplasms may be spread by the larvæ of *Boophilus* and other ticks. In other cases, where the specific blood-parasite has a longer term of development, the larvæ hatched from infected eggs are not infective, nor are the nymphs into which they transform; though both larva and nymph are infected. Here, as Lounsbury has shown, the development of the specific parasite is not complete until the generation inheriting the infection has become adult, and it is the adult that is infective. In this way a malignant jaundice in dogs, due to a specific piroplasma, is transmitted by adults of a *Hæmaphysallis* and a *Rhipicephalus* that have inherited their infection from their female parent.

There are other possibilities, as where a larva or a nymph imbibing blood from an infected animal incubates the infection and becomes infective in the stage immediately following—the larva when it becomes a nymph; the nymph when it becomes adult.

A tick once infected appears to be actually or potentially infective for the rest of its life. Nuttall has found the piroplasma of malignant jaundice of dogs in a *Hæmaphysallis* after seven months' starvation, and he thinks it possible that an infected tick (presumably inheriting its infection) may transmit the infection to its offspring even though it itself should feed on a healthy animal.

Synopsis of Genera of Ixodinæ.

1.	Anal groove arching anteriorly; ventral surface of male entirely covered with chitinous plates; no eyes	*Ixodes.*
	Anal groove, if present, arching posteriorly; ventral surface of male not entirely chitinous	= 2.
2.	Rostrum long; in any ambiguous case the coxæ of the fourth pair of legs are not much larger than any of the other coxæ	= 3.
	Rostrum short; in any ambiguous case the coxæ of the fourth pair of legs are particularly large	= 5.
3.	No eyes; no adanal plates	*Aponomma.*
	Eyes present	= 4.
4.	Stigmata triangular with rounded angles. No adanal plates	*Amblyomma.*
	Stigmata comma-shaped. Adanal plates in male	*Hyalomma.*
5.	No eyes; 2nd segment of pedipalps laterally angulated or acute. No adanal plates	*Hæmaphysallis.*
	Eyes present; 2nd segment of pedipalps not laterally acute	= 6.
6.	Capitulum quadrangular; no adanal plates	= *Dermatocentor.*
	Capitulum hexagonal; no adanal plates	= *Rhipicentor.*
	Capitulum hexagonal; adanal plates in male	= 7.

7.	Stigmata comma-shaped; anal groove present	= *Rhipicephalus*.
	Stigmata oval or circular; no anal groove	= 8.
8.	Two pairs of adanal plates in male; legs normal	*Boophilus*.
	One pair of fused adanal plates in male; segments of legs remarkably expanded, particularly in male	*Margaropus*.

Ixodes, Latreille (ἰξώδης = a sticker). The anal groove arching in front of the anus is characteristic. The rostrum is moderately long; the hind edge of the body is not festooned; there are no eyes; and in the male the whole, or the greater part, of the venter is covered by chitinous plates. Neumann recognises forty-six valid species, distributed in every part of the world. Perhaps the commonest and most notorious species is *Ixodes ricinus*, which is found in Europe, Asia, North Africa, and North America, and among its numerous hosts includes all the common domestic animals, and occasionally man. Neumann separates as distinct subgenera two species, in which the pedipalps of the male are cylindrical in section; one of these (*Eschatocephalus*), found on various bats in the Palæarctic Region, has the pedipalps spatulate; the other (*Ceratixodes*), found on aquatic birds in Polar seas has the pedipalps acute.

Aponomma, Neumann (ἄπονος = untroubled with; ὄμμα = eye). The body is subcircular, at least in the male, and the scutum often is spotted in green or golden yellow. Neumann admits eleven species, distributed in Africa and the Oriental and Australian regions, and parasitic almost exclusively on reptiles.

Amblyomma, Koch (ἀμβλύς = weak; ὄμμα = eye). The body is rather broadly oval, and often there are lustrous metallic markings on the scutum. According to Neumann there are seventy-three valid species at present known, distributed in the Ethiopian, Oriental, Australian, and Neotropical regions (see p. 7). Though they very rarely attack birds, they are parasitic on all other kinds of land vertebrates.

Hyalomma, Koch (ὕαλος = clear; ὄμμα = eye). Males of this genus are easily distinguished from males of *Amblyomma* by the presence of adanal plates. Females can generally be distinguished from those of *Amblyomma* by the more elongate-oval body and by the comma-shaped stigmata. Neumann accepts four species, widely distributed in South

Europe, Asia, and Africa, and parasitic on mammals and tortoises, and occasionally on lizards and birds.

Dermatocentor, Koch (δέρμα = skin; κέντωρ = goader). The rostrum is generally short, but sometimes the pedipalps are almost as long as those of certain species of *Amblyomma* and *Hyalomma;* in such ambiguous cases the distinguishing character of *Dermatocentor* is the large size of the coxæ of the fourth pair of legs. From all other ticks with short rostrum *Dermatocentor* is distinguished either by the quadrangular basis capituli or by the subquadrangular 2nd segment of the pedipalps. The scutum is often marked with conspicuous golden spots. Neumann allows nine valid species, distributed in Europe, Asia, Africa, and America. *Dermatocentor reticulatus* var. *occidentalis* is said to be the infective agent of Rocky Mountain Spotted Fever; in this species the scutum is brown with white markings, the 2nd segment of the pedipalps has a recurved dorsal spine, and the coxæ of the fourth pair of legs are bluntly produced posteriorly.

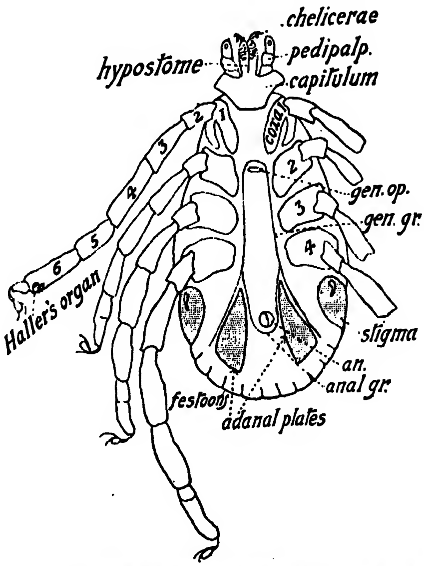

FIG. 121.—*Rhipicephalus sanguineus*, male, ventral view.

Hæmaphysallis, Koch (αἷμα = blood; φυσαλλίς = bladder). The species are, as a rule, easily distinguished by the form of the 2nd segment of the pedipalps (Fig. 122), which has the

outer side angulated or produced into a spur. Neumann considers eighteen species to be valid, and they are found in all parts of the world, most of the domestic mammals being included among their victims.

Rhipicephalus, Koch (Fig. 121) (ῥίψ = wickerwork basket; κεφαλή = head). A hexagonal basis capituli distinguishes the species of this and the two following genera. The stigmata are comma-shaped or subtriangular, and the usual anal groove is present. Neumann tabulates twenty-three species, chiefly African, but also found in South Europe, the Oriental and the Neotropical regions, their hosts being usually mammals, but occasionally birds. *Rhipicephalus sanguineus* is a common parasite of domestic animals and has a distribution coextensive with the genus. *Rhipicephalus gladiger*,

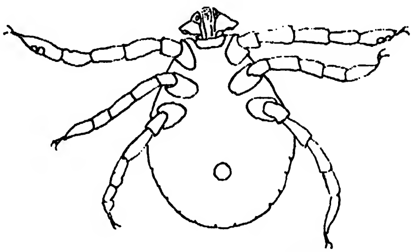

FIG. 122.—Larva of *Hæmaphysallis*.

Neumann, characterised by the enormous spurs of the coxæ of the fourth pair of legs, is according to Neumann identical with Nuttall and Warburton's *Rhipicentor*.

Boophilus, Curtice (βοῦς = ox; φιλεῖν = to love). Differs from *Rhipicephalus* in the absence of an anal groove, the absence of festoons, and the circular or broadly oval stigmata. Neumann is content with one species, *B. annulatus*, which he splits into six subspecies. *B. annulatus* is one of the commonest and most widely distributed ticks of cattle and other domestic animals, and is notorious as the principal carrier of the piroplasma of bovine red-water fever. The larva of *Boophilus* sticks to one host in all its transformations into the adult stage.

Margaropus, Karsch (μάργαρος = a pearl-oyster; πούς = foot). Differs from *Boophilus* only in having the coxæ of the first pair of legs not bifid, and in the form of the legs.

The segments of the legs are expanded, the femur, tibia, and protarsus of the hind legs of the male being enormously broadened; in the female only the distal ends of the segments are expanded. Only one species, *M. lounsburyi*, Neumann, from South Africa, is known, its hosts being horses and cattle. Neumann does not separate *Margaropus* from *Boophilus*.

Subfamily ARGANTINÆ: Soft-ticks.

In this subfamily there is no dorsal shield, or scutum; the capitulum in the adult is inferior, so that nothing—except, perhaps, the tips of the pedipalps—is visible in a dorsal view, and it lies in a shallow depression known as the *camerostome;* the spiracles are small, and lie behind and above the coxæ of the third pair of legs on either side; the pedipalps are not rigid and are composed of 4 nearly equal segments; the legs are attached between two low longitudinal folds—the *supra-coxal* and sub-*coxal folds*, on the former of which the eyes, when they are present, are situated; the coxæ are unarmed, and the pulvillus is absent or vestigial. There is no marked difference between the two sexes; but the male is smaller and has a semilunar genital pore.

The Argantinæ do not, at any rate in their adult stage, attach themselves permanently to a host, but have more the habits of bed-bugs, hiding in crevices, and creeping out—as a rule in the night-time—to suck blood. They are parasitic on birds and mammals, and at least two species have acquired infamy by their habitual attacks on man in certain parts of the world, and by the subsequent effects of their bite.

They do not die as soon as they have once reproduced their species, but they live and grow (as is evidenced by the frequent moulting of the cuticle) for years, and the female produces more than one batch of eggs.

The larva when first hatched has the capitulum anterior, almost as in the Ixodinæ, but later the capitulum becomes pushed into an inferior position by the growth of the fore part of the body.

From the medical standpoint the soft-ticks are of greater interest than the Ixodinæ, since they are more definitely human parasites. Exaggerated statements may, perhaps,

have been made regarding the intrinsic danger of their bite, but there is plenty of evidence that it may be very painful, and that it often causes severe and prolonged irritation, and even spreading inflammation and suppuration, so much so as to support the belief that the saliva is toxic. Several species are, however, known to be the ordinary agents in spreading the infection of certain dangerous or fatal spirochætous diseases of man and birds, which, of course, is a much more serious matter.

Neumann as well as Nuttall and his colleagues recognise two genera of this subfamily.

Synopsis of Genera of Argantinæ.

1. Body in ordinary circumstances flat with a thin striated edge which is defined by a distinct suture *Argas.*
2. Body with a blunt edge which is not in any special way differentiated or demarcated *Ornithodorus.*

Argas, Latreille (Gr. ἀργᾶς = shining).

The body as a rule is flat and more or less oval, with a thin sharp striated margin, which is defined by a conspicuous suture. General integument finely wrinkled and beset with small chitinous platelets more or less distinctly arranged in radial lines. Capitulum as a rule entirely inferior in adult and nymph. Coxal folds often inconspicuous. Eyes absent.

Neumann recognises eight species, two of which, namely, *A. persicus* and *A. reflexus*, are notorious malefactors.

Synopsis of Species of Argas (after Neumann).

1.	Body elliptical (sides curved)	= 2.
	Body oblong (sides straight), culminating anteriorly in a point	= 7.
2.	Body transversely oval	*A. vespertilionis* (on bats in Europe and Africa).
	Body elongate oval	= 3.
3.	Margin of body finely striated	= 4.
	Margin of body formed by quadrangular areolæ	= *A. persicus.*
4.	Body flat; wrinkling of integument very plain	= 5.
	Body tumid, elongate; wrinkling of integument very fine; coxæ of fourth legs near the anterior third of the body	*A. hermanii* (Egypt and Abyssinia).

5. { Body oval, distinctly narrowed anteriorly *A. reflexus.*
Body elliptical, blunt and hardly narrowed anteriorly = 6.

6. { Body twice as long as broad; basis capituli narrowed posteriorly = *A. cucumerinus* (Peru).
Body hardly longer than broad, basis capituli rectangular and well in front of coxæ of first pair of legs = *A. transgariepinus* (South Africa).

7. { Dorsal integument with large polygonal depressions; tarsi with well-marked dorsal terminal protuberance, giving an appearance of a bifid tip = *A. brumptii* (on man in Somaliland).
Dorsal integument almost smooth; tarsi not appearing bifid = *A. æqualis* (German East Africa).

Argas persicus (Oken); the Fowl-tick (Fig. 123). The body is flat, oval, and narrowed anteriorly; general integu-

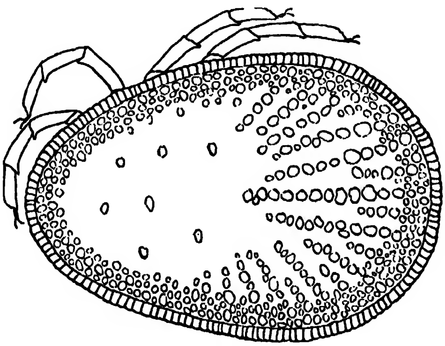

FIG. 123.—*Argas persicus.*

ment finely wrinkled, almost granulous, with numerous platelets; margins formed of quadrangular areolæ; basis capituli broader than long. Found on birds, but particularly on fowls, ducks, geese, and turkeys, in all parts of the world; in Persia it is said to attack man commonly. It lives in cracks of walls, particularly of poultry-houses. It is fatal to fowls by spreading among them the specific spirillum of chicken cholera; but when it attacks a fowl in force the envenomed bites and the loss of blood alone are sufficient to cause death. In Persia its bite is feared by natives, and is said to be actually dangerous to foreigners.

According to observations collected and confirmed by Nuttall, the eggs are laid in batches in the cracks where the ticks hide, and begin to hatch in about three weeks. The larva, which has three pairs of legs and an anterior capitulum,

begins to feed at once if it can, remaining attached to its victim for several days, like an Ixodine. In warm weather the larva may moult into the first nymph stage in about eight days after leaving its victim, but in Nuttall's experiments in spring-time, in England, the time taken was more than six weeks. If the nymph can feed at once it may transform into the next, or *deutonymph* stage, in two or three weeks; and some weeks later—provided it finds food—the deutonymph becomes adult. In Lounsbury's experiments in South Africa the complete life-circle, from egg to egg, occupied about ten months; so that adults may live some time before they begin to generate. A larva kept unfed dies, according to Lounsbury, within eight weeks, but unfed nymphs are said to be able to live for at least a year, and unfed adults for more than three years.

Argas reflexus (Fabr.). This species differs from *A. persicus* in having the front end of the body more sharply narrowed, the margin finely striated, and the basis capituli as long as broad. It is found on poultry, but has a predilection for pigeons and is a known inhabitant of pigeon-cotes; it also may attack man. Its geographical range according to Neumann, includes Europe, North Africa, and North and South America. Its bite may be fatal to pigeons, and may cause much local inflammation in man.

Ornithodorus, Koch (ὄρνις = a bird; δορός = a leather bag). Body either flattish or rotund, commonly oval or oblong, often with the front end narrowed or pointed, its margin thick and not specially defined in any way. Integument mammillose or papillose; coxal folds usually conspicuous; constant pre-anal and post-anal furrows present. Capitulum inferior, but the tip of the pedipalps may be visible in a dorsal view. Eyes, when present, two pairs, situated on the supracoxal fold.

Neumann recognises twelve species as valid.

Synopsis of Species of Ornithodorus (after Neumann).

1. { Hypostome unarmed; integument in nymphal stage (and in places in the adult stage) spinulose; lateral constrictions between cephalothorax and abdomen very distinct . . . *O. megninii.*
   Hypostome armed with recurved teeth as usual; integument not spinulose . . . = 2.

2. Camerostome with movable lateral flaps *O. talaje.*
Camerostome without any movable laterals flaps = 3.

3. Anterior border of distal segments of legs with tubercles or festoons = 4.
Anterior border of segments of legs not tuberous or festooned = 8.

4. Body not much contracted anteriorly = 5.
Body pointed anteriorly = 7.

5. Tubercles of distal segments of legs higher than broad, distant = 6.
Festoons of distal segments of legs as broad as high, contiguous = *O. pavimentosus* (Namaqualand).

6. Eyes present = *O. savignyi.*
No eyes = *O. moubata.*

7. Eyes present = *O. coriaceus.*
No eyes = *O. turicata.*

8. Integument with fine radiating wrinkles = *O lahorensis.*
Integument granulous = 9.

9. Tarsi appearing bifid at tip = *O. furcosus* (Ecuador).
Tarsi not appearing bifid at tip = 10.

10. Tarsi of first pair of legs with three dorsal tubercles, of the other legs with one = *O. canestrinii* (Persia, Asia Minor).
Tarsi without dorsal tubercles, or with one only = 11.

11. Tarsi of last three pairs of legs with a pronounced dorsal protuberance = *O. tholozanii* (Persia, Asia Minor).
Tarsi of legs with dorsal protuberance indistinct = *O. erraticus* (North Africa).

Ornithodorus moubata, Murray (Fig. 124). Body oval, with the lateral notch between cephalothorax and abdomen not very conspicuous; integument mammillose, very sparsely hairy; distal segments of legs fringed with tubercles on the anterior border. This species is very common in Africa, harbouring in native huts, in cracks in the mud floors and in chinks in the walls and thatch; as it is said to creep into the natives' bundles it gets widely spread along the highways of trade. Its bite *per se* is said to be very painful, and to cause long-lasting swelling and itching; but a far more serious possibility is infection with the Spirillum of African relapsing fever.

A female tick becoming infected with this spirillum not only becomes itself infective (and probably remains infective for the rest of its life), but it also transmits the infection to its eggs and so to the next generation, and possibly to further generations. According to the observations and experiments of Leishman, the infection remains fast chiefly

in the Malpighian tubules of the tick, in a sort of latent form, and is transmitted not by way of the salivary glands,

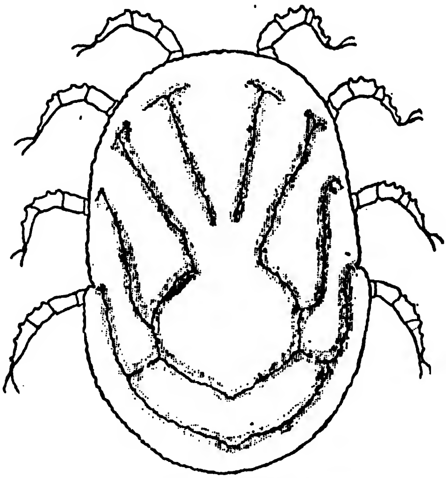

FIG. 124.—*Ornithodorus moubata.*

but by the bite becoming contaminated with the excreta of the tick, at the moment of its infliction. (The Malpighian

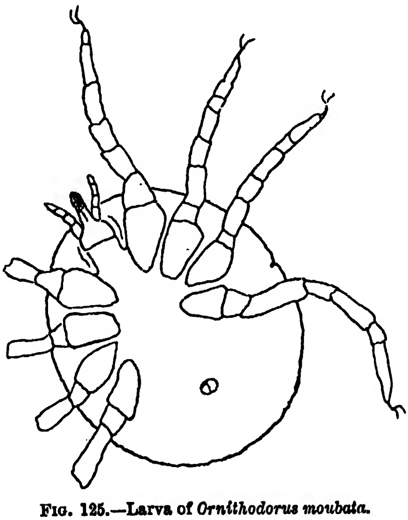

FIG. 125.—Larva of *Ornithodorus moubata.*

tubules open into the rectum, and—as is the case with so many other suctorial Arthropoda—the act of sucking is accompanied by the expulsion of excreta.)

The adults of *O. moubata* probably live for years. The eggs are laid in a clump on or in the ground. The larva does its first moult within the egg-shell, so that when it actually issues from the egg (in about eight days to three weeks) it has four pairs of legs (Fig. 125).

According to Christy, *O. moubata* is capable of transmitting *Filaria perstans.*

Ornithodorus Savignyi (Audouin). Differs from *O. moubata* in having two pairs of eyes, which are situated on the supracoxal folds—one pair above the first coxæ, the other pair above the second intercoxal space; it is also more hairy, and the tarsus of the fourth pair of legs is longer and slenderer. It is found in many parts of Africa, and also at Aden and in South India.

Ornithodorus coriaceus, Koch. Body distinctly though bluntly pointed in front; integument with mammillose areas separated by smooth reticulose areas. Found in California, Mexico, and Paraguay. Attacks man.

Ornithodorus turicata (Dugès). Body elongate-oblong, with nearly parallel sides and a distinct acuminate point at the front end, the point covering the mouth-parts. Found in Tropical America. It attacks man, and its bite is said to cause suppuration and ulceration.

Ornithodorus megninii (Dugès). The body is rudely hourglass-shaped, the lateral constriction between cephalothorax and abdomen being very conspicuous. Integument finely granular and punctate. Hypostome unarmed. In the larva the integument is spinulose. Found in the tropical and subtropical parts of America. It attacks the ears of cattle, occasionally of man also.

Ornithodorus talaje (Guèrin). Body elongate-pentagonal, the front end forming a distinct point which covers the mouth-parts. There are lateral movable lips to the triangular camerostome. The typical form is found in Mexico and South America. A variety is found in various islands of the South Atlantic and Indian oceans. Another variety is known from Venice and the neighbourhood of the Sea of Aral. It attacks man, and its bite is said to be very painful.

Nuttall, with his usual sedulous care, has noticed the measures that, in different places have been adopted against

these ticks—*Argas* and *Ornithodorus*—that annoy man. Fire is the best method for temporary structures; and for permanent buildings the free and frequent use of powerful poisons, such as petroleum, perchloride of mercury, turpentine, etc., and the application of lime-wash or hot tar, etc. Infested fowls should be isolated in crates and separately treated, and the crates subsequently be burnt.

Family SPELAEORHYNCHIDÆ.

(Gr. σπήλαιος = a cavern; ῥύγχος = beak.)

Related to the Ixodidæ and Gamasidæ.

Body broad and flat, with a dorsal scutum, and a small sternum, or "plastron," between the coxæ. The capitulum is anterior; dorsally it is semicircular in outline, ventrally it appears as a cavern in the depths of which lie the chelicerae and hypostome. The chelicerae end in lateral hooks, but the hypostome is a slender unarmed style. Pedipalps slender, composed of 5 segments. The anus is ventral and subterminal, and the genital pore lies immediately in front of it. The stigmata lie above and behind the third pair of legs.

One species is known, from a bat, in Pernambuco.

Neumann places this curious form with the *Ixodidæ*, separating it as a subfamily.

CHAPTER XXV

Order Acarina (*continued*): The Mites

FAMILY *Gamasidæ;* Insect-mites. The species of this large family are quite like small *Ixodinæ*, but the cheliceræ are either chelate or styliform and are often exsertile and retractile; the pedipalps usually consist of 5 segments; the hypostome is styliform, the hind margin of the body is never festooned; eyes are never present, and the stigmata are placed above and behind the coxæ of the third pair of legs.

Some of the *Gamasidæ* are predaceous on mites and small insects; others are parasitic, mostly on insects, but also on mammals, particularly on bats, and on birds; and certain species live in ant-nests. *Raillietia* lives on the ears of cattle and horses. *Dermanyssus* is parasitic on birds; one species (*D. gallinæ*) attacks fowls, hiding in crevices by day and emerging to suck blood at night; this and other species of Gamasidæ occasionally attack man. *Pneumonyssus* was found in the lungs of a monkey. *Rhinonyssus* occurs in the nasal cavities of birds. Of the *Gamasidæ* found on flying insects, many, it is thought, are not truly parasites, but merely use the insect as a means of transport.

Family *Uropodidæ;* Stalked-mites. Minute predaceous mites very much like *Gamasidæ*, but having the spiracles behind the second pair of legs. The retractile, chelate cheliceræ are of relatively enormous length. The nymph attaches itself to insects, as a means of transport, by a long viscid stalk which is secreted by a pair of adanal glands—hence the name of the family.

Family *Trombidiidæ.* The typical members of this family are large bright red mites, known from the nature of their integument as Velvet-mites; their pedipalps (Fig. 127)

are characteristic. Many of them are predaceous on other mites and on insects, some are parasitic on animals, and some, such as the well-known "red-spiders," are very destructive to plants.

The larvæ of *Trombidiinæ* may affix themselves to the human skin, and when they are numerous, as they are at

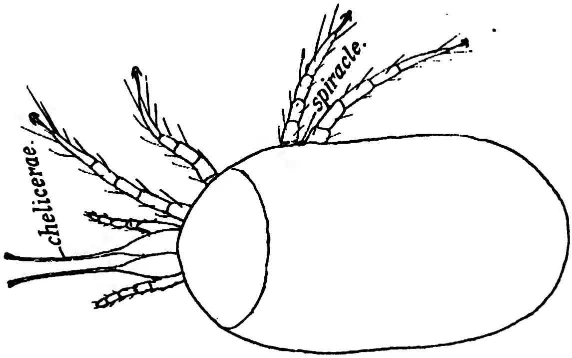

FIG. 126.—*Dermanyssus*, from a Fowl.

certain seasons, they will give rise to erythema and intolerable itching. These larvæ, which are known in all parts of the world, and in Britain are called Harvest-mites, are microscopic in size, round or oval in shape, red in colour, and have three pairs of legs. They are produced in great numbers from eggs which have been deposited by the parent on the ground.

FIG. 127.—Pedipalp of a Velvet-mite.

The best treatment for this "autumnal erythema" is, if the skin has not been very much broken by scratching, to apply a compress or a bandage freely moistened with a lotion of subacetate of lead, or perchloride of mercury, or sulphate of copper. If this be not possible the part should be painted with a mixture of Friar's Balsam (℥j) and Menthol (gr. xxx). Some recommend sulphur ointment.

The disease known as Japanese River Fever has been said to be due to the attack of some larval Acarine of this or some allied family.

Family SARCOPTIDÆ: Itch- and Scab-mites.
(Gr. σάρξ = flesh; κοπτεῖν = to pierce.)

This is a notorious family of minute parasitic mites, most of which live on mammals and birds, sometimes merely attaching themselves to the hairs or feathers, but often burrowing into the epidermis and causing eczematous affections such as itch, mange, and scab.

The body is generally squat-ovate, though sometimes of fantastic shape, and shows no division of cephalothorax and abdomen; anteriorly there is a rostrum formed chiefly by the chelicerae, which usually are chelate, and the short, 3-segmented, more or less adherent pedipalps; posteriorly in the male there are usually suckers. The cuticle is soft, finely striated transversely, and is produced at definite points into long stiff bristles, or coarse spinules. The legs, which are attached ventrally by chitinous supporting-rods, are stumpy and are arranged in two sets, two pairs being placed near the rostrum and two pairs near the hinder end of the body; the tarsi, or some of them, generally end in a sucker.

Of the five subfamilies into which the group is subdivided the most important from the medical standpoint is that of the *Sarcoptinæ*, or common itch- and mange-mites. The species of this subfamily attack the epidermis of man and the epidermic structures of mammals and birds. Their body is round or broadly ovate, their cuticle is transversely striated, and some of their legs end in a long-stalked sucker. In the common itch-mite of man, *Sarcoptes scabiei*, the male is only about half the size of the female, and has suckers on all the legs except the third pair, the female having them only on the first two pairs; the third pair of legs of the male, and the third and fourth pairs of the female, end in a long bristle. The female burrows down as far as the juicy Malpighian layer, depositing a row of eggs as she goes, and ultimately dies at the end of the burrow. The eggs hatch in a few days, and the young are pushed up to the surface,

and are set free by the normal process of proliferation and desquamation of the epidermis. Pairing occurs while the female is still in the nymph stage, and when the fertilised nymph has become adult she starts a burrow of her own. The irritation caused by the mites leads to scratching, such as Thersites desired for Ajax, which increases the eczema and also spreads the infection. The severity of the inflammation depends upon its duration and on the habits of the patient—whether cleanly or not. In a mild attack that is attended to at once, there will only be a few small vesicles or pustules on the back of the hand, near the finger-clefts; in a neglected case in a dirty person all parts except the head and face may be affected. The parasite seems to spread from one individual to another solely by contact. Treatment consists in the free use of soap and hot water and the liberal application of sulphur ointment, continued for several days. Some prefer baths of potassa sulphurata (1 oz. of the salt to 4 gallons of water). Clothing and bedding should be fumigated with sulphur, and baked. There are other species of *Sarcoptes* that attack domestic animals.

The genus *Psoroptes* is distinguished from *Sarcoptes* by having the stalk of the suckers segmented, and the cheliceræ non-chelate. One species is a notorious cause of scab in sheep.

The genus *Chorioptes* includes several species that attack farm-animals and cause mange and scab. In this genus the body is not so squat as in *Sarcoptes*, the male has the third pair of legs very much larger than the fourth, and the female has suckers on the fourth pair of legs.

The species of *Otodectes* live in the ears of dogs and cats, and may cause much suffering. The legs in this genus are slenderer than in Sarcoptes, and in the male the third pair are much larger than the fourth.

Cnemidocoptes is parasitic on birds, the species attacking and loosening sometimes the feathers sometimes the scales of the legs. The females are distinguished from those of other itch-mites by not having a sucker at the end of any of the legs.

The treatment of all these parasitic skin affections of domestic animals is in principle the same as that of itch in man—lotions and dips of potassa sulphurata, or of sulphur

and lime, and greasy applications containing tar, sulphur, precipitate of mercury, or plain petroleum. Infected yards, stables, fowl-houses, etc., should be thoroughly washed out with any good insecticide solution that is available, and then tarred or white-washed.

The other subfamilies of *Sarcoptidæ* are the following:—

(2) *Canestriniinæ.* Parasites of beetles and other insects.

(3) *Analginæ;* Bird-mites. Usually living on the feathers. The body is often fantastically shaped. One species is known to have a *Hypopus* stage (see p. 291), in which it burrows into the subcutaneous areolar tissue and even into the air-passages of its host.

(4) *Listiophorinæ.* Parasites of bats and other small mammals. The body is curiously shaped, and some of the appendages are specially modified for grasping the hairs of the host.

(5) *Cytolichinæ.* Parasitic on fowls. They resemble the itch-mite but have a smaller rostrum. They sometimes burrow into the subcutaneous areolar tissue, and invade and even obstruct the air-passages.

Family *Tarsonemidæ.* A small family of minute, soft-bodied, usually transparent mites, parasitic on plants, to which they cause much damage. The mites may creep on to men handling infested plants, and may give rise to erythema and intolerable itching, due probably to some venomous secretion. In this family the chelicerae are needle-like, the pedipalps are hardly visible, the last two pairs of legs lie far behind the first two pairs, and in the female there is a club-shaped organ between the first and second pairs of legs on either side.

Pediculoides is parasitic on insects, and the pregnant female in the species of this genus becomes like a small jigger by distension of the abdomen. In the swollen abdomen the eggs hatch, and the young complete their development, to issue from the mother as adults.

Family *Tyroglyphidæ* (τυρός = cheese; γλύφειν = to hollow out); Cheese-mites (Fig. 129). Soft-bodied, light-coloured mites, usually with a distinct cephalothorax; integument smooth or granulous; chelicerae usually chelate and projecting like a rostrum; pedipalps small; legs of moderate length,

ending in a claw and often a sucker; in the first two pairs of legs there is usually a clubbed hair near the base of the tarsi, and a very long hair near the base of the preceding joint. These mites eat almost anything, and often do great damage to dried provisions, flour, grain and other seeds, drugs, hay, museum specimens, entomological collections, etc. They multiply very rapidly. The larva has three pairs of legs, and either proceeds by successive moults, in the ordinary way, to the adult stage; or may, after reaching the eight-legged nymph stage, transform into a quiescent *Hypopus* stage in which it emigrates abroad by affixing itself to some

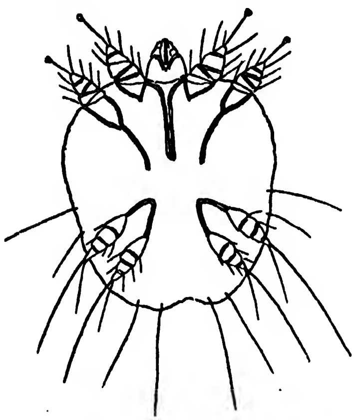

FIG. 128.—Female Itch-mite, ventral view.

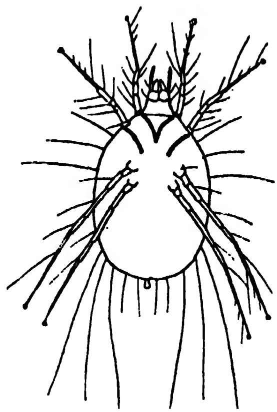

FIG. 129.—Female Sugar-mite, ventral view.

actively locomotive insect, this being effected by a patch of suckers situated at the hind end of its body on the ventral surface.

The *Hypopus*, which is exceedingly minute, has a hard chitinous integument and stumpy legs: it does not feed, having the mouth and its appendages quite vestigial. When it has been carried to some suitable locality, distant from its overpopulated birthplace, it again transforms at a moult into a nymph and resumes the even tenour of its development. The "Hypopus question" furnished abundant material for speculation, until Michael showed by experiment that it is an ordinary alternative developmental stage favourable to the spread of the species by emigration.

The *Tyroglyphidæ* may concern the medical officer not only by their ravages among food-stuffs, but also as sometimes getting on to people who have to deal with infested provisions, and causing the skin-disease known as grocer's itch. Occasionally also they or their eggs may be swallowed in cheese or dried fruit, and if they are numerous may cause dysenteric symptoms.

Some of the species of *Glycyphagus* have a predilection for sugar; in them the integument is rough, the claws of the legs are very inconspicuous, and some of the hairs of the body are feathered.

Tyroglyphus includes the familiar cheese-mite, which lives in all sorts of provisions besides cheese. The dorsal integument is smooth; the cephalothorax is separated from the abdomen by a suture; the pedipalps are inconspicuous; the legs end in a distinct claw and a sucker, and the first leg of the male is not thickened.

The genus *Aleurobius* (ἄλευρον=flour) includes the single well-known species *A. farinæ*, which infests flour and grain as well as other provisions. It differs from *Tyroglyphus* chiefly in having the pedipalps quite distinct from the rostrum and the first leg of the male thickened.

The species of *Carpoglyphus* are found in dried fruit and jam. The integument is smooth, there is no suture between the cephalothorax and abdomen, and the claws of the legs arise from the tip of a membranous extension of the tarsus.

Family *Demodicidæ*. The minute mites of the one genus *Demodex* that constitutes this family live in the sebaceous glands of mammals and several of the domestic animals. The body is elongate and tapering, and its hinder part is superficially ringed and almost worm-like. The appendages are stumpy. These microscopic parasites do little or no harm to their hosts.

Family *Eriophyidæ* (*Phytoptidæ*). Minute mites that form galls, blisters, and excrescences on the plants on which they live. They resemble the *Demodicidæ* in general form, but have only two pairs of legs.

The mites of the following eight families are of no particular importance from the medical standpoint:—

Family *Bdellidæ:* Snout-mites. Usually red in colour. Cephalothorax distinctly delimited from the abdomen and bearing an eye, or eyes, at its posterior angles. The cheliceræ are more or less united to form a "snout." The pedipalps are often long and elbowed. The legs are long and slender. The *Bdellidæ* are predaceous, feeding on other mites and on small insects of all sorts, and are undoubtedly useful to man.

Family *Cheyletidæ.* Tiny mites resembling Snout-mites, but distinguished by their massive, prehensile (cheliform or subcheliform) pedipalps. They are actively predaceous on other mites.

Family *Myobiidæ:* Mouse-mites. Small white mites parasitic on small mammals, particularly on mice. In some respects they resemble itch-mites (*Sarcoptidæ*), but the legs end in claws, and in one genus (*Myobia*) the first pair of legs are very short and thick and end in a great hook, something like the tarsal claw of a crab-louse, for grasping hair.

Family *Hydrachnidæ.* Aquatic mites, mostly living in fresh water, though some are found in brackish and salt water. There is no distinction between cephalothorax and abdomen, and the legs are fringed with long hairs, for swimming. The adults are predaceous on small aquatic animals, including insect-larvæ. The larvæ are commonly parasitic on aquatic animals, sometimes on mosquito-larvæ. The larva has very small appendages, and as it becomes distended with the juices of its host it looks like an egg.

Family *Halacaridæ.* Marine mites, with a distinct, movable head. They crawl about on seaweeds and zoophytes, and are for the most part carnivorous.

Family *Oribatidæ.* Mites with a hard, often dark-coloured, beetle-like integument. The cephalothorax, which carries the appendages, is generally distinctly demarcated from the high, dome-like abdomen. Near the posterior angle of the cephalothorax, on either side, there is a pore, or *pseudostigma*, out of which springs a stout, usually club-shaped bristle. In one group the cephalothorax is movably articulated with the abdomen so that the mite can roll itself up. The species of this family are neither parasitic nor predaceous.

Family *Holothyreidæ.* Mites as big as lady-birds, with a hard, polished cuticle, a scutum covering the whole dorsum of the body, and long legs. At present only known from certain Indo-Pacific Islands.

Family *Opiliocaridæ.* This family includes a few species of long and rather slender-legged mites in which the abdomen is composed of 10 distinct segments, each of the first 4 of which has a pair of dorsal stigmata. According to Oudemans, it is still doubtful whether they belong to the Acarina or not. Only three species are known, from North Africa, Sicily, and Aden.

CHAPTER XXVI

Scorpions, Spiders, etc.

Order SCORPIONIDEA: Scorpions.

SCORPIONS are found in all warm parts of the world and are dreaded for their sting, though as they are nocturnal and retiring in habit they do not trouble man so much as is commonly supposed. The sting is situated at the tip of the "tail," and consists of a strong spine with a swollen base and sharp tip; in the base there is a pair of poison-glands, and near the tip there are two small openings like the eye of a needle, to give exit to the poison. To bring the sting into action the "tail" is raised and bent forwards over the back until it projects in front of the body.

The body of a scorpion (Fig. 130) consists of two portions —(1) a broader front portion, which is composed of the cephalothorax and the 7 anterior segments of the abdomen, and (2) a narrower "tail," or *post-abdomen*, which consists of the 5 posterior abdominal segments and the terminal (post-anal) spine aforesaid. The integument is strongly chitinised.

The cephalothorax, which carries all the true appendages, is covered dorsally by an unsegmented shield or carapace; on the carapace are the eyes—usually a pair in the middle, and a row of two, three, or five *lateral eyes* in each anterior corner. The ventral surface of the cephalothorax, between the coxæ of the last two pairs of legs is known as the *sternum*, the shape of which is used in classification.

The abdominal segments are all distinct. On the ventral surface of the 1st is the genital flap, which covers the openings of the reproductive organs. On the ventral surface of the 2nd is a pair of comb-like appendages, the *pectines*. On

the ventral surface of each of the next 4 segments there is a pair of breathing-slits (*stigmata*), each of which opens into a cavity containing a close-set series of gill-like leaves—the "lung-books." All these structures are regarded as modified appendages.

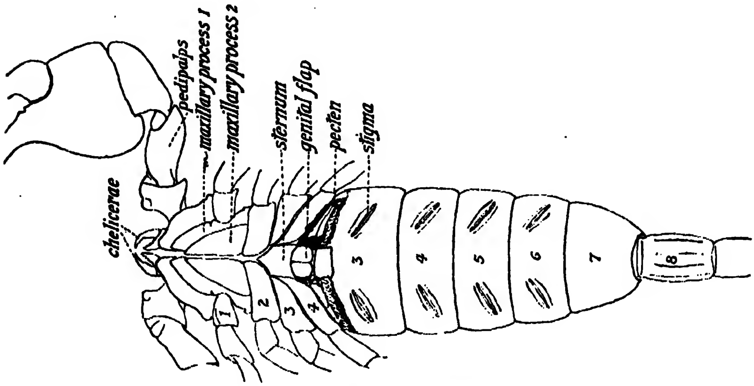

Fig. 130.—Ventral view of Scorpion.

The 5 narrow segments that, with the post-anal spine, form the tail are more or less sculptured and faceted; the anus opens at the end of the 5th. None of these segments has appendages of any sort.

The first pair of cephalothoracic appendages, or *chelicerœ*, are short and pincer-like, and are rather deeply embedded between the second pair. The latter, or *pedipalps*, are large prehensile organs composed of 6 segments, and resemble the great "claws" of a lobster. The next four pairs are crawling-

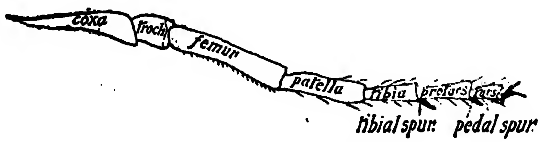

Fig. 131.—Leg of Scorpion.

legs. Each leg (Fig. 131) is composed of 7 segments and ends in a pair of claws. The coxæ of the first two pairs of legs are produced anteriorly into *maxillary processes* (Fig. 130) which form a threshold to the mouth. At the end of the protarsus, or 6th segment of the leg, there is a spine, known as the *pedal spur;* sometimes two pedal spurs are present.

In some scorpions a similar spine is present at the end of the tibia, or 5th segment—the *tibial spur*, or spurs.

The mouth is a chink lying deep between the pedipalps, and opens into a suctorial pharynx. The food consists of insects and spiders, which are seized and held by the "hands" of the pedipalps, are killed by a stab from the post-anal sting, which is bent forwards over the back for the purpose, and are then sucked dry.

The vascular system is very complete, and the blood is blue, as befits a group that has persisted with very little change from Palæozoic times.

The reproductive organs open behind the genital flap on the first abdominal sternum. In the male this flap consists of two distinct halves, but in the female the two halves are more or less united in the middle line. Usually also the male is smaller than the female, and has a larger "hand" and a longer "tail," and larger pectines. The female is viviparous, and often takes some care of the young after they are born.

The venom of the scorpion's sting causes much local inflammation, and also in some species exercises general physiological effects which, according to Calmette, are not unlike those of the venom of Colubrine snakes, causing, when injected into vertebrate animals, muscular paralysis, particularly paralysis of the breathing-mechanism, and destruction of the red blood-cells. Though small doses of the venom have been observed, experimentally, to kill small mammals, the sting of the scorpion is not likely to prove fatal to healthy adult human beings though it sometimes causes severe shock. Scorpion-sting may be treated in the same way as the stings of venomous insects (p. 225).

Scorpions are grouped in seven families, as follow :—

Family 1: *Buthidæ.* The sternum is almost always *triangular;* in a few species it is pentagonal, and in these species (as in many others of the family) the last pair, or last two pairs, of legs have *tibial* spurs. The legs also have a pair of pedal spurs, one of which often is double. Lateral eyes, three or five on each side. Often there is a spine on the swollen base of the "sting." About half the three hundred (or thereabout) species of scorpions known belong to this family, which is represented in all the warm parts of the world.

Family 2: *Scorpionidæ.* Sternum pentagonal (Fig. 130). No tibial spurs. Protarsi with *only one pedal spur.* The claws of the legs lie in a cleft formed by the projecting ends of the sides of the tarsus. Lateral eyes, two or three on each side. Nearly half the remaining species of scorpions belong to this family, which is represented in all warm parts of the world except Southern Europe.

Family 3: *Ischnuridæ.* Differs from the *Scorpionidæ* only in having the body and pedipalps flat and depressed, the tail slender and compressed, and the claws of the legs not overlapped by the sides of the tarsus. A small family of about twenty-four species, found in Africa, Southern Asia, Australia, and (one species only) in Tropical America.

Family 4: *Chærilidæ.* Sternum pentagonal, with a median furrow ending in a pit. No tibial spurs. Protarsi with two pedal spurs. Claws of the legs not overlapped by the sides of the tarsus. Lateral eyes, two (with a yellow glistening spot behind them) on each side. Stigmata circular. About ten species, found only in the Oriental Region.

Family 5: *Chactidæ.* Sternum pentagonal, generally as broad as long. No tibial spurs. Protarsi with two pedal spurs. Claws of legs not overlapped. Lateral eyes, two on each side, but sometimes there are no eyes at all. Stigmata often circular. Between twenty and thirty species, in Tropical America and the countries bordering the Mediterranean Sea.

Family 6: *Vejovidæ.* Sternum pentagonal, generally broader than long, with a deep median furrow. No tibial spurs. Protarsi with two pedal spurs. Lateral eyes, three on each side. Stigmata long and narrow. About twenty species, in South Europe, North Africa, South Asia, and America.

Family 7: *Bothriuridæ.* The sternum consists of a narrow transverse rod divided in the middle line, and is sometimes hardly distinguishable. About twelve species, of which one is Australian and all the others are South American.

Order ARANEIDA: Spiders (Lat. *araneus* = a spider).

In this, the largest order of Arachnida, the body is composed of a well-chitinised cephalothorax, which carries the true appendages, and of an abdomen, which is usually soft and unsegmented, and is attached to the cephalothorax by a short stalk. The integument is more or less hairy.

Ventrally the cephalothorax shows distinct segmentation in the attachment of the appendages and the subdivision of the sternum; but dorsally it is covered by a carapace which at most shows only traces of segmentation. On the carapace are the eyes, which commonly are eight in number and are arranged, more or less distinctly, in two rows.

The first pair of appendages, or *chelicerœ*, are the poison-fangs with which spiders kill their prey. They consist of two pieces—a basal piece containing the poison-gland, and a large curved claw which is perforated near the tip to give exit to the venom, after the manner of a snake's fang.

The second pair of appendages, or *pedipalps*, resemble the legs, except that their basal segment is produced to form a maxillary process. In the adult male the terminal segment of the pedipalps is swollen, and is modified for transferring the sperm to the female.

The legs, which are four pairs, consist of 7 segments and end in two, or three, claws. In those spiders that possess an accessory spinning-plate, or *cribellum*, the protarsus of the hind legs carries a special comb of hairs, or *calamistrum*, which is used for fashioning the threads secreted from the cribellum.

The abdomen, typically, is soft, globular, and unsegmented, but sometimes is horny and angular, or festooned, or spinose, or is very rarely segmented. On its ventral surface, as a rule posteriorly, just in front of the anus, are the *spinnerets*, of which there are commonly three pairs, but sometimes two pairs, or one pair, or very rarely four pairs. The spinnerets, which are regarded as modified appendages, are segmented and mobile, and are perforated at tip by the numerous fine openings of the spinning-glands. Some spiders have, in front of the ordinary spinnerets, a broad spinning-plate, or *cribellum*. The spinning-glands

secrete a viscid fluid, which becomes tough as silk as soon as it is exuded, and is fashioned by the spinnerets and legs into webs, snares, and other structures for trapping or impeding prey, or into nests or "cocoons" for protecting the eggs and young.

The breathing-organs also open on the ventral surface of the abdomen. In most spiders these consist (1) of two lung-sacks, like those of scorpions, which open, anteriorly, one on either side of the genital pore, and (2) of two or more tracheal trunks which open just in front of the spinnerets. In some spiders instead of the tracheæ there is a second pair of lung-sacks lying immediately behind the first pair.

The mouth is a minute pore sunk deeply behind the chelicerae. The food—except in the case of certain very large tropical spiders—consists of insects, which are sucked dry after being killed by the poison-fangs.

The female spider, which greatly exceeds the male in size, produces eggs, in batches, which are enveloped in a silky nest, or "cocoon," and are often guarded or carried about by the mother.

Some spiders chase their prey, and others lie in wait for it. Of the latter some are so coloured as to escape detection, some hide in burrows, and others spin webs and pitfalls of various kinds in which the prey is entangled. A few species live in fresh water, and there are several marine species.

The venom of some spiders is particularly toxic, and the bite of some species is said to cause serious and even fatal results to man. This is said to be particularly the case with the species of *Lathrodectus* which are found in all tropical and subtropical latitudes: they are spiders of no great size, with a globular abdomen, which is often striped, or spotted, or brightly coloured, and longish but fairly stout legs.

The Araneida are divisible into two sections, namely (1) *Mesothelæ*, in which the abdomen is distinctly divided, dorsally, into 9 segments, and the spinnerets are situated in the middle of its ventral surface; and (2) *Opisthothelæ*, in which the abdomen is not segmented, and the spinnerets are posterior.

The *Mesothelæ* include a single genus, which is restricted to the Oriental Region.

The *Opisthothelæ* are divided into two suborders, namely, (1) *Mygalomorpha*, in which the cheliceræ are directed forwards and their fang closes backwards, and the lung-sacks are two pairs; and (2) the *Arachnomorpha*, in which the cheliceræ are directed downwards and the fang closes obliquely inwards, the pedipalps always have a maxillary process, and the breathing-organs consist of one pair of lung-sacks and a pair of tracheæ.

The *Mygalomorpha* for the most part live in burrows which are generally lined with silk. Some of them, known as Trapdoor-spiders, stop the mouth of the burrow with a hinged and very accurately fitted lid which opens outwards. Some of the tropical Mygalomorpha are of very large size, and are said to prey upon small birds and small mammals.

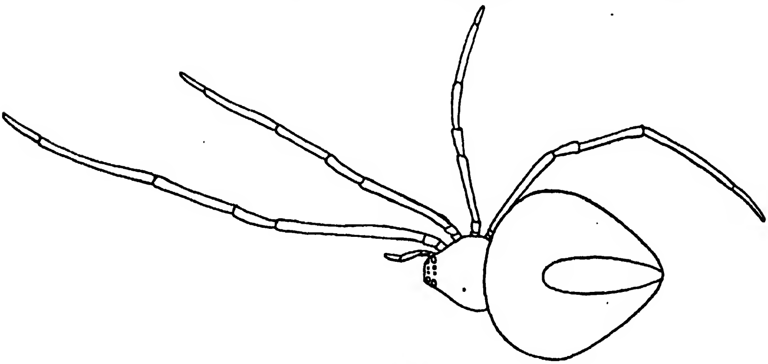

FIG. 182.—*Lathrodectus.*

The *Arachnomorpha*, which include an enormous number of species, are the ordinary familiar spiders. Some of them wander about and run their prey down or leap upon it, others make webs which may either be irregular in form or be beautifully woven of concentric threads on radial stays.

Order SOLIFUGÆ.

Spider-like Arthropods differing from all other Arachnida in having the segments of the body grouped in three regions —head, thorax, and abdomen—like an insect. The head carries the cheliceræ, the pedipalps, and—in the middle of the front border—a pair of eyes. Each chelicera consists of a swollen basal piece and two fangs, which work like pincers;

these are popularly supposed to inflict a most dangerous bite, but all that is actually known about them is that they are used for catching and killing the prey—which consists chiefly of insects. The pedipalps resemble the legs. Between the bases of the cheliceræ there is a little horny spout at the tip of which the mouth opens.

The thorax is composed of 3 independent segments and carries four pairs of legs, which are long, flexible, and hairy, and end in a pair of long, stalked claws; on the hind margin of some of the basal segments of the hind legs there is a series of long, club-shaped, or somewhat racquet-shaped, appanages of unknown function—the *malleoli*.

The abdomen consists of 10 distinct segments; the anus opens on the last, and the genital pore on the first.

The breathing-organs are tracheæ, which open between the coxæ of the second pair of legs, and on the sterna of the 2nd, 3rd, and sometimes the 4th abdominal segments.

The male is distinguishable from the adult female by the form of the first abdominal sternum, which consists of two lateral halves, with lip-like folds covering the genital pore and projecting between them; in the male also there is usually present, on the base of the chelicera, a process known as the *flagellum*.

The Solifugæ are nocturnal and predaceous, hunting their prey with the agility of cats and often taking tremendous leaps. They are found, particularly in arid and desert tracts, in South Europe, Africa, South-west and South Asia, and the warmer parts of America. In Madras they are known as "Jerrymunglums."

They are arranged in the three following families:—

(1) *Galeodidæ*. Stalks of the claws of the legs hairy; abdominal stigmata covered by finely-toothed plates. One genus, *Galeodes*, found in the countries bordering the Mediterranean Sea, South-west Asia, and India.

(2) *Solpugidæ*. Stalks of the claws of the legs not hairy; abdominal stigmata not covered. Many genera and species distributed like the Order.

(3) *Hexisopodidæ*. Some of the segments of the legs spinous; fourth pair of legs without claws. One genus, *Hexisopus*, restricted to South Africa.

CHAPTER XXVII

Appendix to Arachnida

Order PENTASTOMIDA: *Linguatula* and *Porocephalus* (Fig. 133).

THE Pentastomida, though superficially they have some resemblance to parasitic worms, are usually included among the Arthropoda since their muscular tissue is striated; but their life history, for Arthropoda, is unique.

In their adult stage they are internal blood-sucking parasites of various kinds of usually carnivorous vertebrates

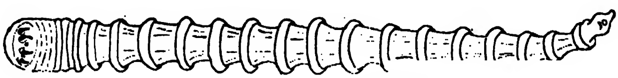

FIG. 133.—Female *Porocephalus*.

(including mammals, birds, and reptiles), and their commonest beats are the nasal and respiratory passages. In their larval stage they are encysted parasites, generally of some animal that is commonly preyed upon by the species in which the adult is parasitic, so that to complete their development two distinct hosts are necessary.

The body, which is flabby and unpigmented, is either cylindrical or flattened, and is often either superficially ringed like that of a worm, or even serially constricted, so as to give a false appearance of segmentation, like that of a tapeworm. There is a distinct head, with a mouth flanked by two pairs of large retractile hooks. On the head also there are numerous symmetrically arranged papillæ, on which epidermal glands open. Some extremely large glands, the secretion of

which is supposed to be hæmolytic, open at the bases of the hooks.

The gut passes straight through the body to the terminal or subterminal anus. The reproductive glands fill the rest of the body-cavity with their coils; they open in the male a short way behind the mouth, in the female just in front of the anus. The male as a rule is smaller than the female.

The eggs, which are produced in myriads, are passed from the body of the parent's host either by the nose or mouth, or in the fæces. Being of microscopic size they are blown about like the dust when once they get free. Most of them must perish, but some of them getting among herbage or into water will be swallowed, and thus may reach a hospitable stomach, where the young can develop.

The minute larva has two pairs of stumpy appendages ending in hooks, and also some anterior chitinous spicules with which it burrows into the wall of its host's stomach, or bores right through the wall and reaches some more vascular organ—commonly the spleen or liver—where it becomes encysted. Sometimes larvæ may wander into some vital part, like the brain, and may cause the death of the host. But in ordinary circumstances the encysted larva remains quiet, growing and moulting, until it becomes a good deal like the parent in form. If at length the host in which the full-grown larvæ are encysted (intermediate host) be eaten by some carnivorous animal, the larvæ may happen upon a second hospitable stomach, from which they may find their way into the nasal passages or lungs, where they attach themselves and become adult in this their final host.

Both as adults and as encysted larvæ Pentastomida have occasionally been found in man.

Three genera are at present recognised, and are all included in a single family, *Linguatulidæ.*

Genus 1: *Linguatula.* Body flat, tapering behind, almost like certain species of flukes, finely ringed like a leech. The adult lives in the nasal sinuses of its host. Both larva and adult have been found in many parts of the world in numerous species of animals, including rabbit, ox, pig, and horse (larva) and dog, sheep, horse, and man (adult).

Genus 2: *Porocephalus* (Fig. 133). Body cylindrical,

elongate, ringed; in some species the rings are so deep cut as to give a deceptive appearance of segmentation almost like a tapeworm, this appearance being quite distinct in the living individual. Found in many parts of the world; the adult commonly in the throat and lung of snakes, the larva encysted in many kinds of animals, including man.

Genus 3: *Reighardia.* Body cylindrical, not ringed. The adult has been found in the air-sacks of certain birds and also in the lung of a viper.

CHAPTER XXVIII

Centipedes and Millipedes

Class MYRIAPODA: (Gr. μυριός = numberless; πούς = foot).

THIS Class includes *inter alia* the Centipedes, whose great poison-claws, which can inflict a very painful wound, entitle them to some consideration here.

In the Myriapoda the body as a rule is elongate and is composed of a head and of numerous segments which, with their appendages, are all nearly alike. The legs are composed of several segments and usually end in a single claw.

The general plan of the head is very similar to that of an insect, the appendages being a pair of many-segmented antennæ, a pair of mandibles, and two pairs—though in many cases only one pair—of maxillæ.

Breathing is performed by tracheæ like those of insects, which have definite openings, usually on the sides of the body.

The Myriapoda are grouped in four orders, as follows:—

1. *Chilopoda*, or Centipedes. There are two pairs of maxillæ. The first pair of legs are much enlarged "poison-claws." The genital pore is on the penultimate segment of the body.

2. *Diplopoda*, or Millipedes. There is only one pair of maxillæ. Most of the body-segments have two pairs of appendages. The genital ducts open on the 2nd or 3rd body-segment.

3. *Pauropoda* (παυρος = few; πούς = foot). Minute Myriapods with nine pairs of legs and triflagellate antennæ. They resemble tiny Centipedes in form; but, like Millipedes, have the genital openings close behind the head, and only one pair of maxillæ.

4. *Symphyla* (συν=connecting; φυλον=clan; signifying that in some respects they appear to connect the Centipede clan with the Insect clan). Minute Myriapods with twelve pairs of legs which end in two claws like those of insects. They resemble tiny Centipedes in form and in having two pairs of maxillæ; but, as with Millipedes, the genital opening is close behind the head.

Order CHILOPODA: Centipedes (Gr. χεῖλος=a lip; πούς=foot).

In Centipedes the body consists of a head, and usually of a large number of flattened segments, all of which except the two last are alike. The head carries a pair of antennæ, which as a rule are composed of very numerous segments; a pair of toothed mandibles, and two pairs of maxillæ, the second pair of which have their bases united to form a lower lip, or *labium*. Eyes are generally present, and in most cases consist of two groups of ocelli placed one on each side of the head.

Of the segments behind the head the two last are small and are a good deal tucked in; the anus opens on the last and the genital duct on the last but one, and neither of them has appendages. But all the other segments carry each a pair of legs, all of which except the first and last are alike, and are composed of seven pieces and a terminal claw. The first pair of legs differ from all the others in the large size of the basal pieces, the enormous development of the claw, and the reduction of the other pieces. These legs are known as "poison-claws," or as foot-jaws (maxillipeds), since their bases are fused with the sternum of their proper segment to form a sort of additional lower lip; the enormous claw is perforated near the tip, like the fang of a serpent, to give exit to the venom, which is secreted by a gland in the base. The last pair of legs differs from all the others in being considerably longer, and occasionally in being also flatter and broader.

The female Centipede as a rule produces eggs, and often guards them until they are hatched. The new-hatched young sometimes resembles the parents, but sometimes has fewer legs.

Centipedes live under stones, dead leaves, and other kinds

of rubbish, in dark and damp places; in the tropics they may creep into a shoe or a bath-sponge. They prey upon insects, worms, and other such creatures, which they kill with their poison-claws. Small Centipedes may creep into the throat and nasal passages, or even into the intestine, of human beings, and may be sneezed, coughed, or vomited up, or even be passed *per anum*, alive. Blanchard has collected a considerable number of such cases.

The "bite" inflicted by the poison-claws of a large Centipede is very painful, and causes numbness and tingling that may last for hours; there is considerable local swelling, which, it is said, may sometimes go on to suppuration and sloughing; beyond this there may be symptoms of constitutional disturbance—sickness and faintness that may continue or recur for some hours. It is sometimes stated that the bite may be fatal, but I think it is an exaggeration to describe it even as dangerous. The treatment is much the same as for stings of venomous insects (p. 225)—astringent and antiseptic lotions applied on lint and covered with guttapercha tissue and bandage, so as to act as a poultice, are very soothing.

Centipedes are commonly grouped in two suborders, namely, (1) *Pleurostigmatiæ*, with stigmata on the sides of some of the segments; and (2) *Notostigmatiæ*, with stigmata on the hind edges of the terga of some of the segments.

Of the *Pleurostigmatiæ* there are four families, characterised as follows:—

Family *Geophilidæ*. Body very long and slender, with 13 to 173 pairs of short legs. Antennæ short, of 14 segments. Stigmata on the pleura of a great many segments. No eyes. Found in all parts of the world.

Family *Scolopendridæ*. Twenty-one to twenty-three pairs of legs, which are fairly long. Antennæ of 17 to 34 segments, much shorter than the body. Eyes, when present, four on each side. Stigmata nine, ten, eleven, or nineteen on each side. The large Centipedes found in the tropics, some of which attain a length of more than 6 inches, belong to this family.

The *Scolopendridæ* are divided into three subfamilies, namely, (a) *Cryptopinæ*, without eyes. Found in all parts of

the world. (b) *Otostigminæ*, with four eyes on each side, and with oval or circular stigmata placed obliquely to the long axis of the body. Found in the tropics all round the globe. (c) *Scolopendridæ*, with four eyes on each side, and with slit-like or triangular stigmata lying parallel to the long axis of the body. Found throughout the tropical and warmer temperate zones.

Family *Craterostigmidæ*. Fifteen pairs of legs. Stigmata five on each side. One eye on each side. One species, restricted to Tasmania.

Family *Lithobiidæ*. Body short. Fifteen pairs of legs. Antennæ of few or many segments, shorter than the body. Stigmata six or seven on each side. Eyes, one or many on each side. Found in all parts of the world.

Of *Notostigmatiæ* there is only one family, namely, *Scutigeridæ*, of very active Centipedes with spidery legs. Body short, with fifteen pairs of long, slender legs of successively increasing length. Antennæ as long as the body, their segments very numerous. The stigmata are buttonhole-like slits in the hind edges of seven of the eight visible terga, and form a median dorsal series. The eyes, of which there are a pair, differ from those of all other Centipedes in being compound and faceted. Found in all warm parts of the world.

Order DIPLOPODA: Millipedes (Gr. διπλοῦς = double; πούς = foot).

The body is cylindrical or semicylindrical, but sometimes is flattened; it can usually be rolled into a flat coil or even into a ball; it is often extremely long, but is sometimes short like that of a wood-louse. The cuticle is generally calcified, and particularly hard.

The head carries a pair of antennæ, which commonly are clubbed and composed of 7 segments; a pair of mandibles, which end in a large tooth and a striated molar facet; and a pair of maxillæ, which, though all their parts are distinctly recognisable, are united to form a lower lip. Behind the head come 4 segments, the first 3 of which have each a pair of legs, while the 4th has none; the genital openings, in both sexes, lie on or near the second pair of these legs, or their coxæ. All the segments behind the first 4—or nearly all—are peculiar in having each two pairs of legs. The legs, which are slender and weak, are attached close together near the mid-ventral line. The last, or anal, segment is larger than any of the others, and its tergum may be produced into a spur. Breathing is carried on by tracheæ; and the stigmata open on the sterna of the

segments close to the articulations of the legs. On the sides of each segment cutaneous glands open, the secretion of which has a pungent smell much like that of prussic acid.

Millipedes live in the ground and under stones. They feed chiefly on vegetable matter, and sometimes do much damage to crops by gnawing the roots. In the tropics, during the rainy season, Millipedes may often be seen collected together on the ground in writhing heaps, exempt from molestation by reason of their pungent cutaneous secretion. Millipedes are found in all parts of the world ; some of the large tropical species are considerably more than 6 inches long.

CHAPTER XXIX

The Class Crustacea

THIS Class includes the crabs, hermit-crabs, lobsters, prawns and shrimps, mantis-shrimps, sandhoppers, wood-lice, fish-lice, barnacles, and water-fleas, as well as a multitude of small aquatic creatures not distinguished in the vernacular. Though of great influence in the world's economy, as scavengers of sea and shore, and as contributing a not inconsiderable part of the food-supply of man, both directly in themselves and indirectly as the pabulum of fishes, they are not of sufficient importance, from a medical standpoint, to demand much notice here. Their chief claim to our attention depends upon the facts that certain small fresh-water species are intermediary hosts of a parasitic worm that causes much discomfort to man in certain tropical countries; that tropical land-crabs of several kinds play a minor part in the service of hygiene; and that the Crustacea that are used as food often give rise to gastric irritation, having troublesome sequelæ, such as nettle-rash.

In the majority of Crustacea the cuticle is strongly calcified, as is implied in the name of the Class (Lat. *crusta* = shell).

Most of the Crustacea are aquatic and breathe by gills which are attached, usually to the thoracic, but sometimes to the abdominal, appendages; but the land-crabs and wood-lice breathe air direct, so long as the air is moist—the land-crab by the lining membrane of the gill-chamber, or by the skin of the abdomen; the wood-lice by special air-spaces, or "pseudotracheæ," in the leaf-like abdominal appendages. On the other hand, many small Crustacea have no special breathing-organs at all.

It is characteristic of Crustacea to have two pairs of antennæ, the anterior pair bearing the diminutive appellation of *antennules;* but one pair, or even both, may be reduced to a vestige, or be entirely suppressed.

In most Crustacea the three pairs of appendages immediately behind the antennæ lie close to the mouth and form jaws. In many, the anterior appendages of the thorax are also crowded beside the mouth and form accessory foot-jaws.

In Crustacea, as in Arthropoda generally, the sexes are separate; but there are numerous sessile and parasitic forms that are hermaphrodite; while among some of the smaller forms—particularly those inhabiting fresh water—males appear only at certain seasons or at long intervals, and in their absence generation after generation is produced by females alone. The ducts of the reproductive organs open on the ventral surface, commonly in the after part of the thorax, but occasionally near one or other end of the body.

The spermatozoa are non-motile. The eggs are numerous and are in most cases carried by the female—either attached directly to some of the appendages, or lodged in a special brood-pouch—until they are hatched, and sometimes even longer. The new-hatched young, or larva (Lat. *larva* = mask) is, in the majority of Crustacea, unlike the parent, and acquires the adult form by a series of post-embryonic developmental changes or *metamorphoses.*

In the higher forms of Crustacea the segments of the body are constantly 21 in number, and are grouped in three regions—head, thorax, and abdomen—the head, however, almost never being sharply separated from the thorax, and often being enclosed with the thorax in a common fold or process of the integument, known as the carapace. In these higher forms, of which the prawn and lobster are types, the appendages of the body number twenty pairs—a pair to each segment except the last, which never carries appendages. The Crustacea which conform to this definite type constitute the subclass MALACOSTRACA.

In the more primitive Crustacea the number of segments and appendages is quite inconstant; there may be few, or there may be a great many, or the segmentation may in cases be quite indistinct. The segments, again, may be

grouped in three regions, or the body behind the head may be almost worm-like in simplicity, or the whole animal may be enclosed in a bivalve shell. In any case the posterior end of the body (abdomen) commonly is destitute of appendages and ends in a pair of long filaments, or "caudal fork." All these inconstant forms are conventionally grouped together as ENTOMOSTRACA.

ENTOMOSTRACA.

In this group, so far as living forms are concerned, four subclasses are included, namely, *Branchiopoda*, *Ostracoda*, *Copepoda*, and *Cirripedia*. None of the Branchiopods and Ostracods are known to be parasitic, but in the other two subclasses many instances of parasitism have been observed, which, although they may not be of any practical importance, are illustrative and suggestive. Among the Copepods, again, we find the necessary "intermediate host" of the guinea-worm—a formidable subcutaneous parasite of man in certain warm countries.

Subclass COPEPODA.

The Copepoda (κώπη = oar; πούς = foot) are found, sometimes in prodigious numbers, in all the waters of the globe, salt and fresh. Many of them are ectoparasites, and not a few are internal parasites, of marine animals: most of the free-living forms are minute, but some of the parasites are of considerable size, one of them—parasitic on a fish—exceeding a foot in length.

In the free-living Copepods the arrangement of the body and appendages is typified by *Cyclops*, described below; but among the parasitic Copepods it is highly diversified and often degraded, and we meet with worm-like forms that have lost their appendages, and with sack-like forms in which the segmentation also has disappeared, curious lobes and excrescences being sometimes developed on various parts of the body. In certain deformed Copepods the females of which are parasitic on fish, the males are dwarfed and live as parasites on the females.

Besides the attached parasites and the internal parasites, there are to be found among the Copepods semi-parasites

and temporary parasites. Of the latter, *Argulus*, a common parasite of both sea and river fish, must be mentioned. In *Argulus* the body is leaf-shaped and ill-segmented; the mouth-parts are suctorial, and in front of the mouth there is a retractile hollow spine connected with large "poison-glands"; the maxillæ are transformed into large adhesive suckers which look like a pair of enormous eyes; and a pair of eyes is present.

The species of the genus *Cyclops* (Fig. 134), some of which are instrumental in carrying the guinea-worm, are typical examples of free-living Copepods, and may be found in abundance in any pond or ditch. They are minute, semi-transparent, or — from the presence of food or fat—

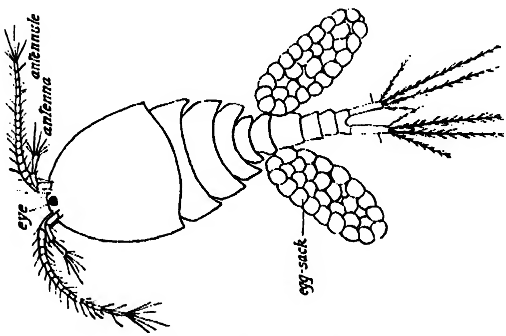

FIG. 134.—Female *Cyclops*, with Egg-sacks.

greenish or reddish creatures, swimming with powerful jerks. Examined under a lens, the body is seen to consist of an anterior oval disk followed by a narrow tail, or abdomen, which ends in a pair of long, feathered filaments. The front of the disk is a true cephalothorax composed of 6 head-segments and 1 thoracic segment, all united and carrying diverse appendages; the posterior half of the disk consists of 4 distinct thoracic segments, each bearing a pair of biramous, jointed, feathery swimming legs.

Of the appendages of the cephalothorax the most conspicuous are the first two pairs—the antennules and antennæ—the antennules, which are the chief organs of locomotion in *Cyclops*, being of great length. Between the antennules, in the mid-dorsal line, is a mass of black or red pigment—the

"nauplius" eye. Behind the antennæ in the mid-ventral line is the mouth, with all the other cephalothoracic appendages crowded together on either side of it: these are the "mouth-parts," and consist, in consecutive order, of a pair of mandibles, two pairs of short, setose maxillæ, and a pair of maxillipeds or foot-jaws.

The tail-like abdomen consists of 4 (female), or 5 (male) segments, all of them destitute of appendages. Attached to the first abdominal segment of the female is often seen a pair of large oval egg-sacks, each of which may be about one-third as long as the animal itself.

If a Cyclops be examined alive in a drop of water, steadied by a cover-glass, the alimentary canal, which pulsates vigorously, can be seen running from the mouth to the cleft of the caudal fork.

To study the development of *Cyclops*, a female carrying egg-sacks should be taken up in a pipette and placed in a small tube of water with a few pieces of duck-weed or a small tuft of a Confervoid. The tube should then be corked for safety, and left in the light. Within a few days, minute whitish specks will be seen flitting through the water and resting on the side of the tube. These are the "nauplius larvæ" of Cyclops.

A *nauplius* examined under a low power of the microscope discloses an oval body with three pairs of setose appendages, of which the first is simple and the other two are biramous. These are the future antennæ and mandibles, though in the present stage they are organs of locomotion. At the fore end of the body, in the middle line, is a mass of pigment—the "nauplius eye," which persists throughout life as the sole organ of vision. Between the mandibles is the mouth, and at the hinder end of the body is the anus. The alimentary tube runs through the body in a straight line, and within it may be seen the diatoms and spores of confervæ taken as food.

In the course of a few days the nauplius is transformed into the adult Cyclops by a succession of moults, in which segments with their appendages, or buds of them, are added at the posterior end of the body, but in front of the terminal portion where the anus is situated.

The nauplius larva is not peculiar to Cyclops, but is characteristic of all the subclasses of the Entomostraca, and may even be said to be characteristic of the Crustacea as a class, since it also crops up among the Malacostraca.

Cyclops in relation to Guinea-worm.—The adult guinea-worm, of which the female only is certainly known, is a subcutaneous parasite of man in India and South-western Asia, in Tropical Africa, and in certain parts of South America. It is a worm that may attain a length of 6 feet. When ripe it causes the formation of an abscess in the skin of its "host," through which it breaks in order to give birth to its myriad progeny of minute embryos. The escaped embryos, which are about ·5 mm. long, if they happen to be washed into a watercourse, attack any convenient species of Cyclops. According to some authorities they bore through the body-wall of the Cyclops, but Leiper thinks that they enter at the mouth. If many embryos attack a single Cyclops the result is fatal; but if only a few enter they, in a term ranging according to temperature from two to eight weeks, undergo a metamorphosis and become quiescent in the living Cyclops. What subsequently happens cannot be certainly affirmed, but it is inferred that if an infected Cyclops happened to be swallowed by a man who is not fastidious about his drinking-water, the quiescent embryo is released when the Cyclops is duly digested, and subsequently fulfils its destiny as a parasite of its final host. But whether the guinea-worm actually reaches man in the envelope of a Cyclops, or whether, as seems less probable, there is another post-Cyclopean stage, there is no doubt about the necessary intermediation of Cyclops.

Prophylaxis against guinea-worm seems, therefore, to be entirely a question of scrupulous attention to sources of drinking-water in places where the parasite occurs. Water containing even uninfected Cyclops is certainly not fit to drink; but if it must perforce be used it should first be boiled. A well known to contain infected Cyclops should (if the populace is sufficiently intelligent not to suspect sinister designs upon life and liberty) be treated with a considerable quantity of *quicklime*, so as to heat the water suddenly. The well must, of course, be left for a time to recover.

Subclass BRANCHIOPODA.

A few Branchiopoda live in the sea and in brine-pools, but the majority are inhabitants of ponds and lakes. They do not come within the range of human pathology, though the smaller members of the group should not be overlooked by an investigator in search of intermediate hosts. Most are small; some are microscopic; the largest attains a length of 2½ inches.

The segmentation of the body varies within wide limits, from as many as 42 segments (in addition to the head) to as few as 6. Large paired eyes (which may be stalked) are usually present, but may be fused together. The appendages of the trunk are usually leaf-like, lobed swimming-feet, which also function as gills; hence the name of the group, from βράγχια = gills, and πούς = foot. Appendages are usually absent from the posterior segments.

The sexes are separate. During the summer months, as a rule, only females are found, and new generations arise from unfertilised eggs; but in the autumn generation males appear, and fertilised "winter-eggs" are then produced which do not hatch until the spring.

The eggs of Branchiopods, if they become desiccated by the drying up of their pools, may retain their power of development for years, until water reaches them again. This fact explains the sudden appearance of Branchiopods in the rare and transient storm-pools of arid countries like Baluchistan.

Branchipus (Fig. 135) is a typical Branchiopod. *Apus* differs from Branchipus chiefly in having the anterior two-thirds of the body enclosed

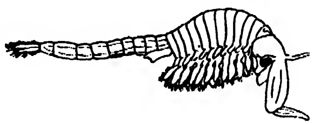

FIG. 135.—*Branchipus.*

in a large horse-shoe carapace, and in the much greater length of the caudal filaments. In *Estheria* the body is completely enclosed in a bivalve shell like that of a small fresh-water mussel. In *Daphnia*, which is one of the smallest of the Branchiopods and consists of few segments, the body is encased in a bivalve shell from which the beak-like head and large antennæ project.

Subclass OSTRACODA.

The *Ostracoda* (ὀστρακώδης = shelly) are abundant both in the sea and in stagnant water. They are of minute size, the largest species known — a relatively gigantic form from the deep sea — being not quite an inch long. The body is completely enclosed in a bivalve shell, is unsegmented or very indistinctly segmented, and carries very few appendages. The spermatozoa of some Ostracods "lick creation," being eight or ten times as long as the animal itself.

Subclass CIRRIPEDIA.

This subclass, which is confined to the sea and its brackish inlets, includes the barnacles and a number of degenerate, unsegmented, often limbless and distorted forms which are either rooted or burrowing parasites of invertebrate marine animals of many kinds. Though fixed as adults, almost all of them begin life as an active nauplius, and pass through a second free-swimming phase (Cypris stage), in which they are enclosed in a bivalve shell and somewhat resemble an Ostracod. From this transitory condition of activity the retrograde change into the sedentary or parasitic adult is sometimes quite extraordinary. Most of the Cirripeds are hermaphrodite, but in some of the parasitic forms the sexes are separate; in both cases dwarf males, parasitic on the hermaphrodite or on the female, are to be found.

The barnacles, which encrust most things, living or inanimate, that float in the sea or are washed by the waves, attach themselves by their head, or rather by their antennules, where lie the openings of special cement-glands for this purpose. The region of attachment is sometimes produced to form a long fleshy stalk. The animal itself is enclosed in a very complete fold of the integument, or mantle, the outer surface of which is fortified by plates of shell. In the mantle-cavity—loose, except for the fixation of the much-transformed head—lies the body of the animal, with six pairs of biramous tendril-like thoracic appendages vibrating at the opening of the shell and raking-in food. In addition to these curly appendages, or cirri, there are three pairs of short mouth-appendages; but the antennules are altered and functionless, and the antennæ disappear altogether.

Among the parasitic Cirripeds the order of *Rhizocephala* may be instanced. These, which infest higher Crustacea, particularly crabs, are, in the adult stage mere swollen bags, without segmentation, without appendages, "sans everything" except ovary and testes. In the absence of an alimentary canal nourishment is absorbed by a mass of rootlets that ramify throughout almost every organ and tissue of the "host" in which they are embedded. A common form is *Sacculina*, parasitic on, or in, crabs. *Sacculina* is hatched as a nauplius, and becomes a "cypris," differing from those of other Cirripeds only in the absence of an alimentary canal. After a brief existence in the free state, the cypris larva first attaches itself to, and then after certain transformations burrows into the crab, and, as an *internal* parasite, undergoes a further remarkable series of transformations, or reconstructions, which end in the formation of the ramifying absorptive roots and the sack-like body of the adult. When these are fully grown the sack-like body breaks through the soft integument of the crab's abdomen and becomes *external*, the roots of attachment and absorption remaining deeply embedded in the tissues of the host.

Subclass MALACOSTRACA.

This subclass, though it contains plenty of small forms, includes all the large Crustacea, and all those that are found in the food-market.

The number of segments is usually 21 (or 20 if the region of attachment of the eyes be excluded), but in one little group (*Nebalia* and allied forms) there are 22 segments. Of the segments 6 are supposed to form the head, 8 compose the thorax, and 7 (or 8 in the little order where *Nebalia* belongs) are abdominal. The abdomen very rarely ends in a caudal fork like that of the Entomostraca.

The terminal segment never carries appendages, but these are, typically, present on all the other segments.

The new-hatched young is generally unlike the adult, but is exceptionally a nauplius.

The Malacostraca are usually distributed in nine orders.

Order DECAPODA.

This Order (δέκα = ten, and πούς = foot), which comprises Prawns, Lobsters, Hermit-crabs, and Crabs, is so called because the five posterior pairs of thoracic appendages are usually long crawling-legs.

The body consists of (1) a large cephalothorax, formed of the head-segments, which are indistinguishably fused, and of the thoracic segments, most of which are immovably united, and of (2) an abdomen formed of 7 segments which are usually distinct and separate.

The cephalothorax is enclosed in a large dorsal shield, or "shell," or *carapace*. The carapace overlaps the cephalothorax on either side, so as to leave a space—the gill-chamber—for the gill-plumes, which are attached to some or all of the appendages of the thorax. Currents of water are drawn through the gill-chambers by peculiarly modified processes of the jaws and foot-jaws and sometimes of some of the legs. These currents usually pass in at the bases of the legs and pass out near the mouth.

In the typical Decapod every segment except the last carries a pair of appendages, but there are numerous forms

in one or both sexes of which some of the abdominal appendages are suppressed.

The appendages of the head are the eyes, which are often carried on stalks; the antennules, which are branched and contain in their basal segment an otocyst or statocyst; the antennæ, on the base of which the excretory organs open; the mandibles, which are strong and tooth-like; the maxillules, and the maxillæ. The last two are branched, lobed, setose plates and lie like leaves on the mandibles.

The appendages of the thorax are not so diversified as those of the head. The first three pairs are more or less intermediate in structure between jaws and legs: they are crowded together in front of the mouth and are known as foot-jaws, or maxillipeds. The last five pairs are strong crawling-legs; any of them may end in nippers (chelæ), and one of them—the first or second—may be enormously enlarged and may end in particularly large and powerful chelæ for tearing and grasping food.

The appendages of the abdomen are, usually, biramous, feathery, or leaf-like swimming-organs. Those of the 6th segment are, commonly, of pre-eminent size, and form with the terminal limbless segment, or telson, a large tail-fan, with which, by powerful strokes of the abdomen, the animal swims backwards. In most Decapods the first two pairs of abdominal appendages of the male are modified in some way for sexual purposes, and many of the abdominal appendages of the female are used for carrying the eggs, being sometimes used exclusively for this purpose (*e.g.* in crabs).

The capacious stomach of the Decapods is furnished with strong calcareous grinders and is a masticatory organ.

The reproductive organs open either on the basal segment of a pair of the thoracic legs, or on the sternum in that vicinity —those of the male on the last pair, those of the female on the antepenultimate pair.

The Decapoda may conveniently be marshalled in three series—MACRURA, ANOMURA, and BRACHYURA.

The MACRURA (μακρός=long, and οὐρά=tail) are the Prawns, Shrimps, Lobsters, and Crayfish. The body is elongate, and the abdomen, which is greatly developed, ends in a large fin-like tail-fan. They live in fresh water as well

as in the sea, and are eaten in all parts of the world. Many of them are scavengers, and though it would be quite unreasonable to condemn salt-water species on this account, the case is altogether different with those that are taken in fresh water, especially in stagnant water in the tropics, which is liable to dangerous and disgusting contamination.

The ANOMURA (ἄνομος = irregular, and οὐρά = tail) include the Hermit-crabs, Rock-hermits, Mole-crabs, and others. In these the body is either less elongate, or may even be squat; the abdomen is less massive, and the tail-fan is reduced, hardly ever forming a large fin. The abdomen either is soft and spirally coiled, or, if well calcified, is more or less bent or rolled under the cephalothorax. Even in the most lobster-like of them the abdomen is flexed, and even in the most crab-like of them there is either a tail-fan or some asymmetry of the abdomen; while the typical hermit-crabs use a cast-off shell as a protection for their soft abdomen. Among the Anomura there is one family—the *Cœnobitidæ*—of dwellers on land, and these are industrious scavengers, especially on the islands and seaboards of the Indo-Pacific. One of the *Cœnobitidæ*—the Robber-crab (*Birgus latro*) of the Indo-Pacific—attains an enormous size and a weight of at least 6 lb.; it is eaten, and is spoken of in the account of Drake's famous voyage of circumnavigation as "good and restorative meat," being an eater of fruit rather than a scavenger.

The BRACHYURA (βραχυς = short, and οὐρά = tail) are well known as crabs. Here the body is rarely elongate, and the abdomen, which is often ill developed, is permanently bent under and more or less concealed by the thorax, and never ends in a tail-fan. The abdominal appendages are reduced, in the males to two pairs, which are modified for sexual purposes, and in the females to four pairs, which are used for the attachment of the eggs. Most of the crabs are marine and littoral, but some of them inhabit brackish water, not a few are amphibious and burrowing; there is one large family that is restricted to fresh water (ponds and streams), and a certain number live on land. The fresh-water and land crabs can be recognised by their broad carapace. All crabs are scavengers, and for this reason the fresh-water

species should be regarded with suspicion in thickly populated areas, and the land-crabs should be avoided altogether as food.

The other *Malacostraca* can merely be mentioned, order by order. None are used as food, though some—and their larvæ—are of economic importance as contributing to the sustenance of fishes. Some of those *Isopoda* that are parasitic on fishes and prawns may come under the notice of the medical officer.

Order LEPTOSTRACA.

The Leptostraca, or Nebaliacea, are small marine Crustacea, only one species—living in the great depths of the sea—exceeding half an inch in length. The tail ends in a caudal fork like that of most Entomostraca, and the anterior half of the body is enclosed in a bivalve shell like that of the Ostracods and certain Phyllopods—only transparent. The eight pairs of thoracic appendages are all alike, and are commonly leaf-like, somewhat resembling those of the Phyllopods. The Nebaliacea differ from all other Malacostraca in having 8 abdominal segments and a long caudal fork.

Order SYNCARIDA.

This order includes two living species, both of small size, of which one is found in mountain pools in Tasmania, and the other in fresh-water pools in South-eastern Australia. They resemble small Amphipoda (see below), the body being elongate and not having a carapace, and all the segments behind the head being distinct from one another; but they differ conspicuously from Amphipods in having biramous, thoracic legs.

Order SCHIZOPODA.

A few members of this order are found in fresh water, but the majority are marine, living at or near the surface of the ocean. Most are quite small, but a comparatively gigantic species from the deep sea attains a length of 6 inches. The Schizopods much resemble small and delicate prawns, from which they are distinguished by the form of the thoracic appendages, all of which, generally, are feathery, *biramous* swimming-feet with gill-plumes (when present) freely projecting from them.

Order CUMACEA.

These are small or minute Crustacea found only on the sea-bottom. They can usually be recognised by their large swollen cephalothorax, the anterior part of which is enclosed in a carapace, by their long and very slender abdomen, and by their strong cuticle.

Order TANAIDACEA.

Minute Crustacea living, often in tubes, at the bottom of the sea. The body is slender and elongate, there is a small carapace which includes the head and the first 2 thoracic segments, and the second pair of thoracic legs are large chelipedes. Except for the presence of a small carapace they resemble Isopoda (see below).

Order ISOPODA.

Of the members of this order the majority are marine, but some live in fresh water and in subterranean waters, and one whole tribe—the wood-louse tribe—is terrestrial. Of the marine species many are parasitic on fishes, on other crustacea (including crustacea that are themselves parasites), and on other marine animals. All degrees of parasitism are illustrated—from predatory ectoparasites showing no sort of deterioration, to sessile ectoparasites and internal parasites so utterly degenerate and deformed as to have lost all resemblance to segmented animals. Among some of these parasites, again, sexual anomalies are frequent: some are hermaphrodite, some begin life as males and end as females, while in others the male is a grub-like dwarf-parasite of the parasitic female. Good instances of this last kind of involved parasitism are supplied by the *Bopyridæ* which are common parasites in the gill-chambers of prawns, etc.

In the free-living Isopoda the body is generally of a broadish oval form, and is well segmented; there is no carapace; the thoracic appendages are strong legs for crawling and clinging; and the abdominal appendages are broad plates for swimming and for respiration. One of the deep-sea Isopods reaches the extraordinary length of nearly 11 inches, but few others attain a quarter this size, and some are quite small. Some Isopods, particularly in tropical seas, burrow into, and do damage to, submerged woodwork.

Order AMPHIPODA.

Most of the Amphipoda are marine and oceanic; some, however, such as the common sandhopper—which is a good type of the order—are

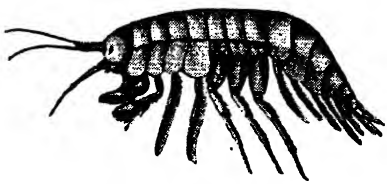

FIG. 186.—*Gammarus.*

littoral and amphibious; not a few live in lakes, streams, wells, and underground waters; a few, such as the whale-lice, are external parasites,

The body in this order is laterally compressed and usually elongate; there is no carapace; the thoracic appendages are legs for crawling and clinging; while of the abdominal appendages the three anterior pairs are feathery swimming feet, and the three posterior pairs are directed backwards and are commonly adapted for springing.

In the typical Amphipods the four anterior pairs of thoracic legs are bent forwards at the base and backwards at the tip, while in the three posterior pairs these directions are reversed—a condition to which the order owes it name. Most Amphipods are small.

Fresh-water species of the widely distributed genus *Gammarus* (Fig. 136) are in some places very destructive to mosquito-larvæ.

Order STOMATOPODA.

The Locust-shrimps, or Mantis-shrimps, are a very well-characterised order of predatory marine Crustacea. The anterior part of the elongate body is covered by a small carapace, which, however, leaves at least the 4 posterior segments free; the abdomen is long and large, and all its segments except the last carry biramous swimming-plates to which the gill-tufts are attached; and the last abdominal segment is a broad spinose plate and forms with the enlarged sixth pair of appendages a powerful tail-fan. The first five pairs of thoracic appendages are prehensile legs, the terminal joint of which is usually sharply serrated and closes against the penultimate joint like the blade of a pocket-knife. The second pair of these remarkable legs is greatly enlarged, and forms a terrible raptorial weapon. The eyes are large and are set on movable stalks, as in the Decapoda and Schizopoda. The largest Stomatopods exceed a foot in length, while the smallest are about 1½ inches long. The Stomatopods either burrow in the mud of the sea-bottom or live in crevices in coral-reefs.

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